elekdoorbell

program your own signature
tune or seasonal melody!

nicads
to charge or not to charge?

i.f. strip and
stereo decoder
for a top-notch vhf-fm receiver.

elektor 50 decoder

Volume 5   **Number 6**

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MEMBER OF THE AUDIT BUREAU OF CIRCULATIONS — **ABC**

- What is a TUN?
- What is 10 n?
- What is the EPS service?
- What is the TQ service?
- What is a missing link?

Semiconductor types
Very often, a large number of
equivalent semiconductors exist
with different type numbers. For
this reason, 'abbreviated' type
numbers are used in Elektor
wherever possible:
- '741' stand for µA741,
  LM741, MC641, MIC741,
  RM741, SN72741, etc.
- 'TUP' or 'TUN' (Transistor,
  Universal, PNP or NPN respect-
  ively) stand for any low fre-
  quency silicon transistor that
  meets the following specifi-
  cations:

UCEO, max	20V
IC, max	100 mA
hfe, min	100
Ptot, max	100 mW
fT, min	100 MHz

Some **'TUN'**s are: BC107, BC108
and BC109 families; 2N3856A,
2N3859, 2N3860, 2N3904,
2N3947, 2N4124. Some **'TUP'**s
are: BC177 and BC178 families;
BC179 family with the possible
exeption of BC159 and BC179;
2N2412, 2N3251, 2N3906,
2N4126, 2N4291.

- 'DUS' or 'DUG' (Diode Univer-
  sal, Silicon or Germanium
  respectively) stands for any
  diode that meets the following
  specifications:

	DUS	DUG
UR, max	25V	20V
IF, max	100mA	35mA
IR, max	1µA	100 µA
Ptot, max	250mW	250mW
CD, max	5pF	10pF

Some **'DUS'**s are: BA127, BA217,
BA218, BA221, BA222, BA317,
BA318, BAX13, BAY61, 1N914,
1N4148.
Some **'DUG'**s are: OA85, OA91,
OA95, AA116.

- 'BC107B', 'BC237B', 'BC547B'
  all refer to the same 'family' of
  almost identical better-quality
  silicon transistors. In general,
  any other member of the same
  family can be used instead.

BC107 (-8, -9) families:
BC107 (-8, -9), BC147 (-8, -9),
BC207 (-8, -9), BC237 (-8, -9),
BC317 (-8, -9), BC347 (-8, -9),
BC547 (-8, -9), BC171 (-2, -3),
BC182 (-3, -4), BC382 (-3, -4),
BC437 (-8, -9), BC414

BC177 (-8, -9) families:
BC177 (-8, -9), BC157 (-8, -9),
BC204 (-5, -6), BC307 (-8, -9),
BC320 (-1, -2), BC350 (-1, -2),
BC557 (-8, -9), BC251 (-2, -3),
BC212 (-3, -4), BC512 (-3, -4),
BC261 (-2, -3), BC416.

Resistor and capacitor values
When giving component values,
decimal points and large numbers

of zeros are avoided wherever
possible. The decimal point is
usually replaced by one of the
following abbreviations:

p	(pico-)	=	10^{-12}
n	(nano-)	=	10^{-9}
µ	(micro-)	=	10^{-6}
m	(milli-)	=	10^{-3}
k	(kilo-)	=	10^{3}
M	(mega-)	=	10^{6}
G	(giga-)	=	10^{9}

A few examples:
Resistance value 2k7: 2700 Ω.
Resistance value 470: 470 Ω.
Capacitance value 4p7: 4.7 pF, or
0.000 000 000 004 7 F . . .
Capacitance value 10n: this is the
international way of writing
10,000 pF or .01 µF, since 1 n is
10^{-9} farads or 1000 pF.
Resistors are ¼ Watt 5% carbon
types, unless otherwise specified.
The DC working voltage of
capacitors (other than electro-
lytics) is normally assumed to be
at least 60 V. As a rule of thumb,
a safe value is usually approxi-
mately twice the DC supply
voltage.

Test voltages
The DC test voltages shown are
measured with a 20 kΩ/V instru-
ment, unless otherwise specified.

U, not V
The international letter symbol
'U' for voltage is often used
instead of the ambiguous 'V'.
'V' is normally reserved for 'volts'.
For instance: $U_b = 10$ V,
not $V_b = 10$ V.

Mains voltages
No mains (power line) voltages
are listed in Elektor circuits. It is
assumed that our readers know
what voltage is standard in their
part of the world!
Readers in countries that use
60 Hz should note that Elektor
circuits are designed for 50 Hz
operation. This will not normally
be a problem; however, in cases
where the mains frequency is used
for synchronisation some modifi-
cation may be required.

Technical services to readers
- **EPS service.** Many Elektor
articles include a lay-out for a
printed circuit board. Some — but
not all — of these boards are avail-
able ready-etched and predrilled.
The 'EPS print service list' in the
current issue always gives a com-
plete list of available boards.
- **Technical queries.** Members of
the technical staff are available to
answer technical queries (relating
to articles published in Elektor)
by telephone on Mondays from
13.30 to 16.45 Letters with
technical queries should be
addressed to: Dept. TQ. Please
enclose a stamped, self addressed
envelope; readers outside U.K.
please enclose an IRC instead of
stamps.
- **Missing link.** Any important
modifications to, additions to,
improvements on or corrections
in Elektor circuits are generally
listed under the heading 'Missing
Link' at the earliest opportunity.

For all their undoubted advantages, batteries have one major disadvantage: they will eventually run out and almost always at the most inconvenient time. There is a remedy to this problem: rechargeable **nicads**.
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contents
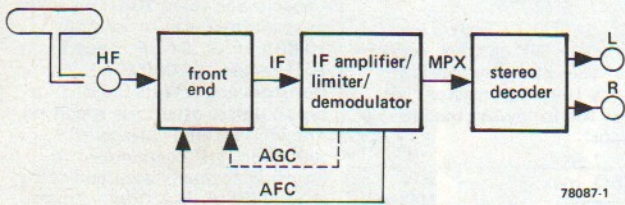
78087-1

Basically, an FM stereo receiver consists of three sections: front-end, IF strip and **stereo decoder**. Several ready-built front-ends are available, and these can be used in conjunction with the **MF IF strip** and **stereo decoder** described in this issue.
p. 6-16 and p. 6-22
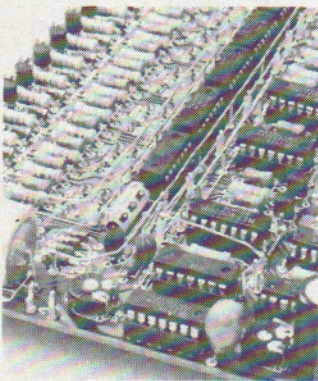
The **monoselektor** is the basis of a remote control system with up to 15 separate channels. It was originally intended as a simple-to-operate remote control unit for the handicapped, but it should also prove useful in many other applications.
p. 6-32

The **elekdoorbell** is the subject of this month's cover: a programmable doorbell that can be built for around a fiver.

Supplement:
BASIC (part **4**), an introduction to a simple computer language.

SELEKTOR

Questions of colour

Dr. M. R. Pointer*

We seem to have become more aware, in recent years, of the colourful world in which we live. Colour television is now as common as black-and-white was ten years ago; people almost invariably use colour film in their cameras; colour supplements and coloured advertisements appear more often in our national newspapers. Why are things coloured? How do we see colour? And how do we measure it?

Out of the whole of the electromagnetic spectrum, stretching from gamma rays to radio waves, only a small band of radiation is capable of stimulating the eye. The limits of this visible spectrum are not well defined but we may think of it as occupying a wavelength band stretching from 380 to 780 nanometres (1 nanometre = 10^{-9} metre); the shorter wavelength represents the blue end of the spectrum and the longer wavelength the red end.

Before we can see a coloured sample we must have a source of light; it is this that provides the electro-magnetic energy or power to which our eye responds. Most light sources can be considered white, but if their spectral power distributions were measured they would show that different lamps provide different amounts of energy at different wavelengths. Even the most basic of light sources, daylight, comes in many forms; generally, however, daylight has more power at the blue end of the spectrum, whereas incandescent or tungsten light tends to be strong in energy at the red end.

Consider now the object that is being illuminated by this white light: if it is coloured, it usually contains a pigment or dye that absorbs light selectively from some parts of the spectrum, so a piece of fabric that has been dyed with a red dye looks red, even though it is being illuminated with white light, because it is absorbing light at the short (blue) and middle (green and yellow) wavelengths but reflecting light at the long (red) wavelength. Similarly, a piece of purple glass must absorb green light and allow the red and blue light to be transmitted to give the visual impression of purple.

Research Division, Kodak Ltd, Harrow, Middlesex
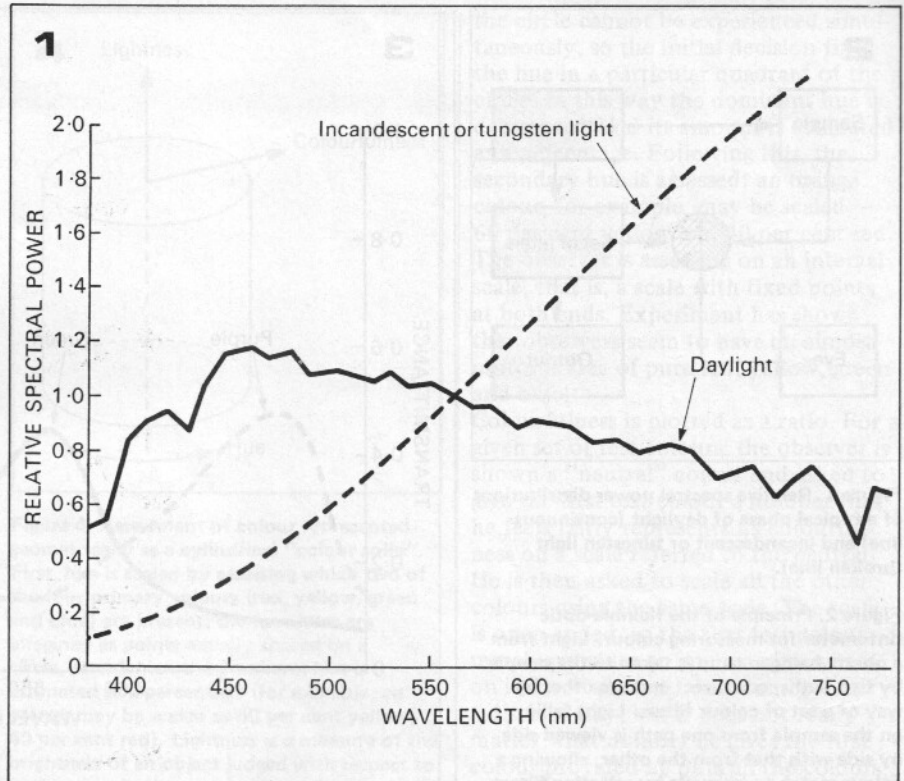
Of course, different white lights render coloured objects in different ways: the predominance of red energy in tungsten light should make red objects appear more red than if they were viewed in daylight, which has less red energy. To some extent the eye allows for these differences in the light sources, an ability known as chromatic adaptation. Colour rendering is a subject of continuous research, specifically by M. B. Halstead in the UK and by other workers in Holland and the USA. One area of particular interest is that of colour preference. For example, do people prefer apples to appear a certain colour regardless of the light source used to illuminate them? Obtaining this sort of information is important to the lamp manufacturer designing new lamps.

Seeing Colour

Light entering the eye is focused on to the retina, the nervous tissue that lines the inner wall of the eyeball. The light receptors, or sensors, known as the rods and cones, are in the layer furthest from the front of the eye, so the light has to pass through several other layers of cells to reach them. Reaction at the receptors is photo-chemical and for colour it is the cones that are important. The rods are for low intensity (scotopic) vision, while the cones operate at high (photopic) intensities. Scotopic vision is in monochrome but photopic vision is in colour.

It is generally supposed that there are three types of cone receptor, some sensitive mainly to long-wavelength light, some to short-wavelength light and some with a peak sensitivity between the two. The chemical substances in the three types of cone that are responsible for the photochemical reactions have yet to be isolated from any one retina, and possible sensitivity curves have been found only indirectly. The idea of three types of cone receptors was first postulated by Thomas Young and supported by Helmholtz, who showed that a colour can be reproduced by only three radiations, such as a red, a green, and a blue, mixed in correct proportions. This trichromatic theory provides the basis for many colour measuring instruments and colour reproduction systems.

Signals generated in the individual receptors are combined and coded in the various cells that come after the rods and cones in the visual system. They are then transmitted out of the eye, along in the optic nerve to the brain. Coding is necessary because it is estimated that there are six million cones in a human retina and only one million nerve fibres leaving the eye. Moreover, those nerve fibres also have to transmit signals from the rods, estimated to number about 100 million. Recent research has suggested that the signals are not really "colour" signals but a luminance signal, composed of the combined red, green and blue signals, and two colour-difference signals. This bears a remarkable resemblance to the transmission of a luminance signal and two chrominance signals that works successfully in colour television.

SELEKTOR
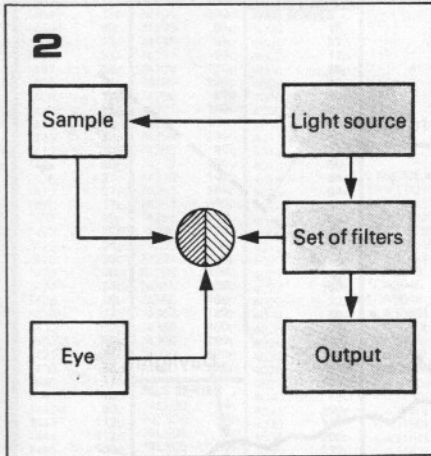
Figure 1. Relative spectral power distributions of a typical phase of daylight (continuous line) and incandescent or tungsten light (broken line).

Figure 2. Principle of the flexible-optic tintometer for measuring colour. Light from a quartz halogen lamp is taken to the sample by two paths, one direct and the other by way of a set of colour filters. Light fallin on the sample from one path is viewed side by side with that from the other, allowing a colour match to be made by selecting filters. Brightness also can be matched by means of a variable aperture. From the known properties of the filters it is possible to derive "red", "green" and "blue" values which can be converted into a set of definitive co-ordinates.

Figure 3. Spectral transmittance of a green glass (continuous line) and a purple one (broken line). The green glass transmits mostly green light; the purple one absorbs green but transmits red and blue.

Measuring Colour

There are three main ways of measuring colour. The first obvious one is by eye. An example of a visual colorimeter is the flexible optic tintometer, designed and developed in the UK, which has been used with great success in quality control laboratories. The instrument contains a quartz halogen lamp to illuminate the sample to be measured (if necessary the light can be taken to the sample by a fibre-optic pipe). It is also used to illuminate filters, comprising sets of red-absorbing, green-absorbing and blue-absorbing glasses of various densities, which are remarkably stable and can be manufactured to a high degree of accuracy and reproducibility. An optical system arranges for the light from the sample and from another beam that passes directly through the filters to be viewed side by side, so that a colour match can be obtained by adjusting the filters. Brightness is also matched, by means of a variable aperture. The known properties
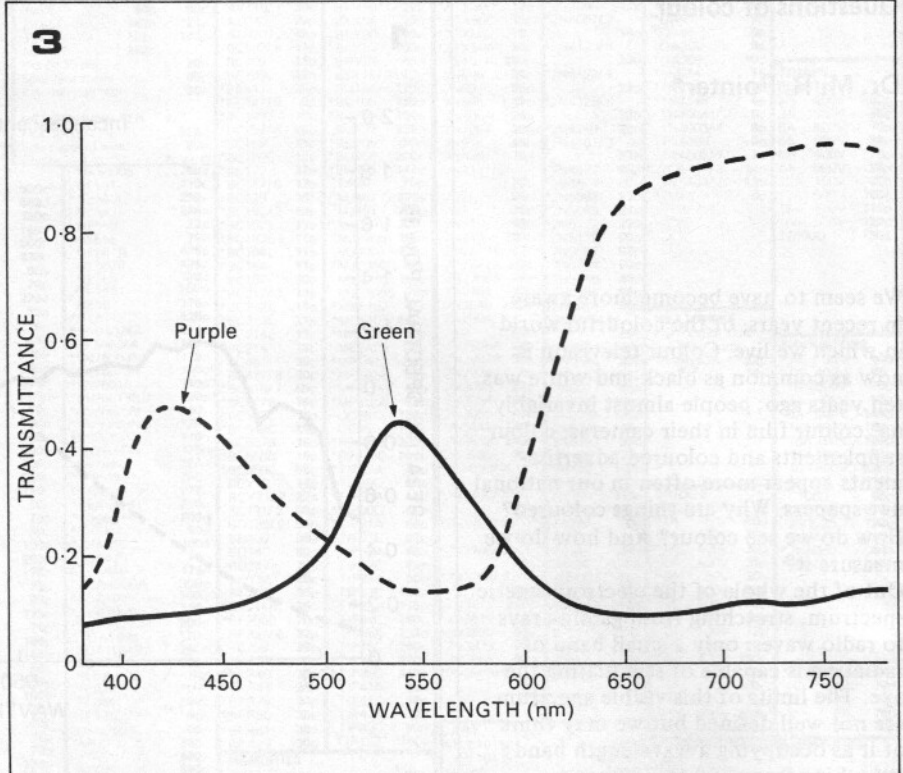
of the filters can be used to derive a "red" value, a "green" value and a "blue" value, and these numbers can be converted into a set of coordinates that enable the colour to be uniquely characterized. This co-ordinate system is adopted by the CIE (Commission Internationale de L'Eclairage) and is used internationally.

The second important way of measuring colour is with the photo-electric colorimeter. It attempts to copy the way the human eye works by using three photocells, with suitable filters over them, to reproduce the spectral responses of the eye's three colour-sensitive channels. An exact match in responses is very difficult to achieve but many modern instruments get very near to it. Modern photo-electric colorimeters, usually from the USA, are often popular because of the speed with which they work. They incorporate microprocessors that enable the results to be displayed in a number of different co-ordinate systems. The difference between the colour being measured and a standard colour stored in the memory of the microprocessor can also be displayed.

Spectrophotometry

The third way of measuring colour is with the spectrophotometer. This does not measure the "red", "green" and "blue" values directly, but the relative amount of energy reflected from or transmitted by a sample in terms of wavelength. A typical instrument uses a white light source, usually a quartz halogen lamp, to illuminate a grating which produces a spectrum of light in

the wavelength range 220 to 900 nm. A deuterium lamp is used for the ultra-violet or short-wavelength end of the spectrum because the quartz halogen lamp is not a good source of ultra-violet energy. A relatively new British spectrophotometer uses a holographic grating instead of the more traditional ruled-glass grating, thereby reducing the amount of stray light in the instrument by an order of magnitude — a significant improvement. Older instruments used one or two glass prisms to produce the spectrum but these are bulky and expensive to make and disperse red wavelengths less than blue.

The spectrum produced by the grating is scanned past a slit, which is variable and is used to define the bandwidth. The beam of light is then split into two beams by, for example, a rotating mirror system. When transmission is being measured, one of the beams goes through the sample and the other straight to the detector. The energy in the two beams is then compared by detecting the light with a photomultiplier, giving a measurement of the attenuation that has taken place in the sample. By scanning the spectrum past the slit it is possible to measure the whole spectral response curve and trace it out on a chart recorder. The latest spectrophotometers incorporate microprocessors and are able to store the data needed to control a particular scan, such as the wavelength at which the scan starts, the finishing wavelength, the scan speed and so on. These data can also be recorded in a computer coupled to the instrument and the spectral data can be

SELEKTOR

stored while they are being generated by the instrument. It is possible to control the spectrophotometer directly from the computer, too, by sending it the necessary scanning information.

The CIE have been able to specify the colour matching characteristics of a "standard observer", based on the results of about 20 real observers. The CIE has also standardized several light sources by tabulating their spectral power distributions. Two of these are Standard Illuminant S_A, representing incandescent illumination, and Standard Illuminant D_{65} representing a phase of daylight which has a correlated colour temperature of about 6500K. By integrating the spectral transmittance or reflectance data, obtained from the spectrophotometer, with a specified illuminant and each of the three spectral response curves of the standard observer in turn, "red", "green" and "blue" values can be calculated. In this way it is possible to measure, or calculate, a unique specification for any colour in terms of three numbers.

The accuracy varies from one instrument to another. For example, if the precision of a spectrophotometer is to match that of the human eye, the spectral transmittance, or reflectance, has to be measured to within 0.4 per cent of the correct value for a random error or to within 0.2 per cent for an error varying systematically with wavelength.

Appearance of Colour

Measurements by colorimetry tell us only approximately what the colour looks like in particular viewing conditions. The appearance of a colour is affected by many external influences such as the level and spectral composition of the illumination used to view it, the luminance and chromaticity of the area surrounding the colour, familiarity with the object and knowledge of its particular colour, and whatever colour was seen by the viewer immediately beforehand (the eye retains an after-image for a short time). We have developed a technique in our laboratory to assess the appearance of a colour in the conditions in which it is viewed. Dr R. W. G. Hunt, also of the Kodak Research Laboratories, has suggested and defined a framework of terms for the observers to use, some of them new to colour science.

Basic Attributes

Colour sensations have three basic attributes, namely hue, brightness and colourfulness. The brightness of an object is often judged with respect to a white one in the same surroundings and light, a measure referred to as lightness. Colourfulness is a new term that is the subjective measure of the chro-

Figure 4. Assessment of colour represented geometrically as a cylindrical "colour solid". First, hue is scaled by assessing which two of the four primary colours (red, yellow, green and blue) are present; the four hues are imagined as points equally spaced on a circle, after which the dominant hue is estimated as a percentage (for example, an orange may be scaled as 60 per cent yellow, 40 per cent red). Lightness is a measure of the brightness of an object judged with respect to a white one in the same surroundings and light, and is represented on a scale with one end representing black, or zero, and the other end white, or 100. If the hue circle is just one slice from the cylinder, lightness is the distance of the slice from the bottom of the cylinder. Colourfulness is a subjective measure of chromatic content: judged in proportion to the brightness of a colour, it is the degree of saturation; in proportion to the average brightness of the surroundings it is called "perceived chroma".

matic content of a colour. If this is judged in proportion to the brightness of the colour, the measure is expressed as the degree of saturation; if judged in proportion to the average brightness of the surroundings the term used is perceived chroma. If a coloured cushion is seen partly lit by direct lighting and partly in shadow, its colourfulness in the two parts is different because the level of illumination is different, but the saturation is the same and the perceived chroma is, too, for although the illumination level is different, the brightness of the cushion and the brightness of the surroundings are lower in the shadow area, and these factors are taken into account.

Several experiments have shown that observers can scale hue, colourfulness and lightness of a colour on a purely psychological basis. Hue of a test colour can be scaled by first assessing which two of the four primary colours, red, yellow, green and blue, are present. These four hues can be imagined as points equally spaced on a hue circle; hues at opposite ends of a diameter of

the circle cannot be experienced simultaneously, so the initial decision fixes the hue in a particular quadrant of the circle. In this way the dominant hue is determined and its amount is estimated as a percentage. Following this, the secondary hue is assessed: an orange colour, for example, may be scaled 60 per cent yellow and 40 per cent red. The observer is assessing on an interval scale, that is, a scale with fixed points at both ends. Experiment has shown that observers seem to have an almost uniform idea of pure red, yellow, green and blue.

Colourfulness is plotted as a ratio. For a given set of test colours, the observer is shown a "neutral" colour and asked to give the first test colour a number that he feels fairly represents its colourfulness on a scale referred to the neutral. He is then asked to scale all the other colours using the same scale. The scale is open-ended, so the first test colour merely provides an anchor somewhere on it. Each observer uses numbers in a distinct way, but it does not really matter what number he gives the first colour provided he puts all the colours he sees subsequently on the same scale.

Geometric Terms

The difference between observers means that ordinary arithmetical statistics cannot have any meaning, so the geometric mean must be taken to find an average. In geometrical terms we can think of colourfulness as the radial distance of the colour from the centre of the hue circle, the centre representing the neutral point. Lightness is scaled on an interval scale. One end represents black, or zero, and the other end represents white, or 100. Geometrically, if the hue circle is thought of as being just one slice from a cylinder, lightness is the distance of the slice from the bottom of the cylinder.

Experience shows that these ideas can be easily accepted by observers and that they can scale colours easily, not only consistently on their own but with good general agreement with one another. Work is now going on to try to relate these subjective assessments to objective measures, with proper allowance for the other parameters that define a particular scene and influence the appearance of a colour in that scene.

Colour science has many facets. It depends on instruments that give objective measures and on human observers, who can provide reliable, subjective measures. But those of us who have an interest in colour science may share the thoughts of Alice in the book by Lewis Carroll: "It's all very pretty," said Alice, "but it seems rather hard to understand."

Spectrum No. 160.

(478 S)

Nicads

To charge or not to charge?

For all their undoubted advantages, batteries have one major disadvantage, they will eventually run out and almost always at the most inconvenient time. The pain in our wallet is a familiar feeling as the time for replacing them arrives since they, like everything else today, do not get any cheaper. If you are a consistent 'sufferer', there is a remedy for this problem, namely rechargeable nicads. Although initially more expensive than conventional batteries they offer considerable savings in both money and convenience.
Assuming one observes a few elementary rules when using nicads, they should have an extremely long life.
The following article takes a look at the type of applications for which nicads are particularly suitable — i.e. when they will prove more economical than primary cells — and explains how their effective life can be prolonged by careful use.
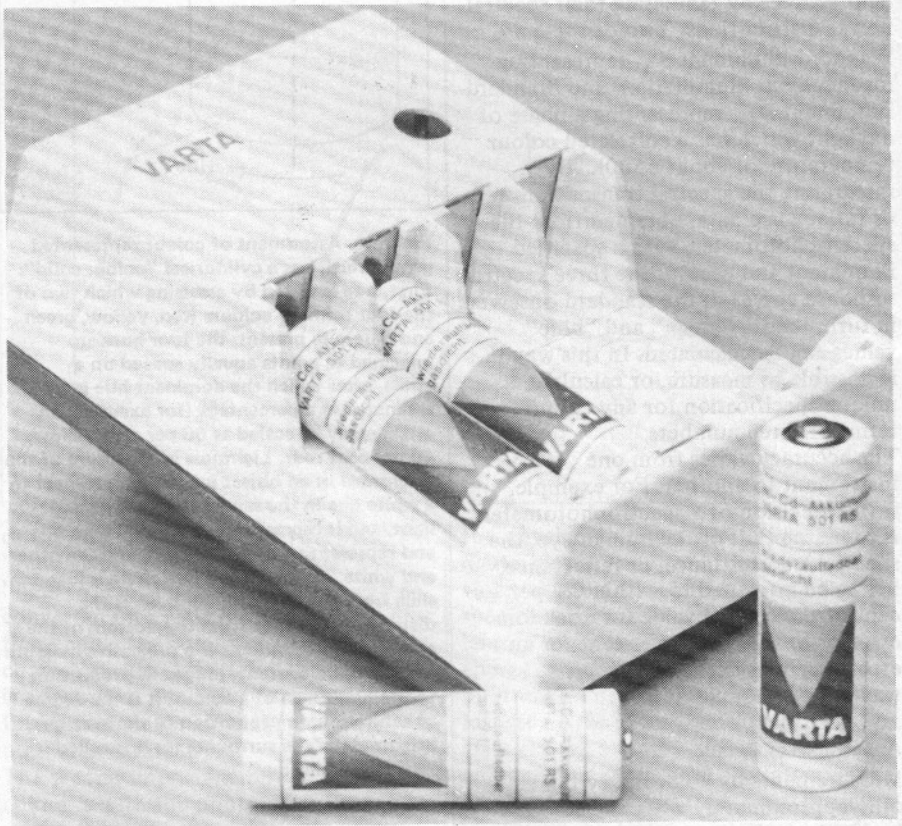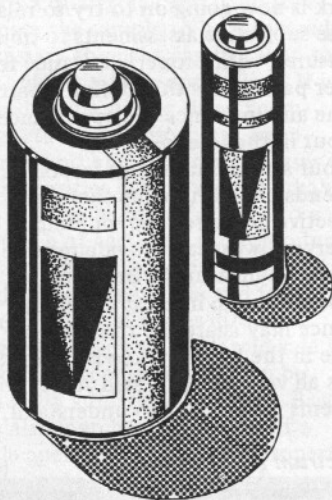
There are a number of factors to consider when faced with the choice of using conventional 'dry' batteries or rechargeable nicads. Although nicads could cost as much as three times the price of dry batteries, the fact that they are rechargeable offers a potential saving in the long term. They are mechanically robust, less prone to electrolyte-seepage than dry cells, have an extremely low internal resistance, and a virtually constant voltage for over 90% of the discharge period.
The latter two features are particularly useful. The low internal resistance means that it is possible to connect larger numbers of nicad cells in series and allows higher flash frequencies in battery-operated flash units, whilst the stable working voltage means that there is less chance of pocket calculators becoming unreliable as the batteries begin to run down. Similarly, there is less risk of cassette recorders or cine-cameras slowing down during recording or filming — a problem encountered with dry batteries which are exhausted but can 'feign' a normally charged state when switched on after periods of disuse. Nicads are much more honest:

they either provide a current at a steady voltage or nothing at all.
However nicads also have one or two disadvantages: the average discharge voltage is only 1.2 V (as opposed to 1.5 V for dry batteries), so that for example, 4 'D' cells (HP 2) would provide only 4.8 V, instead of 6 V. Not every piece of equipment will operate satisfactorily with a 20% reduction in supply voltage. This, in turn, may lead to over-frequent recharging, since only the first third of the discharge cycle (when the working voltage may exceed 1.2 V) is then used.
Generally speaking the capacity of nicads and of conventional primary cells is roughly the same, although there are special manganese-alkali cells with greater capabilities than those of nicads. However it must be borne in mind that the capacity of a cell, and in particular zinc-carbon primary cells, is to a greater or lesser extent dependent upon the discharge rate. Nicads are particularly suited to high discharge rates and continuous use, whereas primary dry cells are intended for intermittent service at lower discharge currents. Thus a nicad will have a

Table 1a

I.E.C. no.	RO3	KR 15/51	KR 27/50	KR 35/62	6F 22
U.S.A.S.I.	AAA	AA	C	D	—
Berec dry cells	U16	HP7	HP11	HP2	PP3
Varta nicad cells	18RS	501RS	RS 1.8 K	RS 4 K	TR 7/8
SAFT nicad cells	—	VR 0.5	VR 2 c	VR 40	—
Berec nicad cells	—	RX6	RX14	RX20	RX22

Table 1b

	HP7 AA	HP11 C	HP2 D	PP3 —
Nominal voltage dry cell	1.5 V	1.5 V	1.5 V	9 V
Nominal voltage nicad cell/battery	1.2 V	1.2 V	1.2 V	9.0 V
capacity (Ah) dry cell/battery	0.15-2	0.4-6	1-10	0.05-5
Capacity (Ah) standard (sinterelectrode) nicad cell/battery	0.5 / 0.45	1.8 / 2.0 / 1.65	+	0.09 / 0.11

All capacities stated at 5 hour discharge rate, temp. = 20°C

greater effective capacity in such applications as a cassette recorder being operated for long periods.

The capacity of nicad batteries of identical dimensions often differs from manufacturer to manufacturer. However in contrast to dry batteries, the nominal capacity of nicads is always indicated on the case, and these figures can be compared directly with one another.

Of course the single greatest advantage of nicads, namely the fact that they are rechargeable, inevitably entails a practical inconvenience for the user — the need for a charger.

Choosing the right battery — shape, capacity, charge time and price

Having decided to opt for the use of nicads there comes the question of which type of cell to buy. If the nicads are being used to replace conventional dry batteries, then the choice of size is already decided. Table 1a shows the more commonly available nicad equivalents for popular dry cells, while table 1b lists their basic differences.

In the case of dry cells, the effective capacity can vary by as much as a factor of 10, depending upon the type of cell and the discharge rate. The lower figure as a rule refers to standard zinc-carbon cells operating under unfavourable discharge conditions (5 hour continuous discharge), whilst the higher figure refers to manganese-alkali cells.

The nominal capacity of nicad cells is usually expressed for a five hour discharge C/5. That is to say, the capacity which is obtained when fully charged cells are discharged at such a rate as to bring them to an end point of 1.0 V in 5 hours. The figures obtained for a one hour discharge are approximately 10 to 15% lower, whilst a longer discharge period of 10 hours results in a negligible increase in capacity.

The influence of the discharge current on the cell voltage and on the cell capacity (as a result of increased internal resistance) is slightly greater in the case of smaller cells (capacity less than 100 mAh), but is still virtually negligible when compared to conventional dry cells. A number of manufacturers produce cells of different capacity for a given size, thus for example it is possible to buy AA cells with a 0.5 and

0.6 Ah capacity.

The time taken to fully recharge a standard sintered nicad cell is approximately 14 hours, assuming the maximum normal charging current is used (i.e. the cell is not being fast-charged with the aid of a charger which will automatically switch off once the fully-charged state is reached). Charging at the normal rate can be done with a very simple circuit (e.g. a half-wave rectifier plus series resistor).

If shorter charge times are desired, then there are specially designed quick-charge cells which will accept three times the normal charging current. With these cells the charge cycle is completed in 4 to 6 hours. In addition, it is possible to use automatic quick-chargers, which are capable of fast-charging the cell in 15 to 60 minutes. Depending upon the manufacturer, these 'superchargers' can be used with special quick-charge sintered nicad cells or ordinary standard sintered nicads. Generally speaking, however, successful operation is only guaranteed if both the charger and cells are from the same manufacturer. Naturally, these quick-charge units are fairly expensive. The use of fast chargers

is discussed in more detail later in the article.

Points to check before buying a nicad cell

1) Make sure that the equipment or circuit in question will operate satisfactorily at the lower supply voltage provided by the nicad(s). In the case of battery-operated devices this should not normally present a problem. To obtain reasonable use from the battery the equipment should continue to function properly with a 1 V cell voltage.

2) Check to see whether the equivalent nicad cell will actually fit into the battery compartment of the equipment for which it is intended. In the case of cylindrical cells there should be no difficulty, however it can happen that the 9 V battery packs will not fit, even though they conform to IEC 6F22 dimensions.

Using Nicads
Charge cycle

Nicads are normally charged with a constant current of roughly one tenth of the cell's nominal capacity. It should be stressed that the charging current must be fairly constant (or limited to a safe value). Due to the very low internal resistance of nicad cells, constant voltage charging is to be avoided, since there would then be the possibility of very high currents being drawn by the cell, leading to overheating or thermal runaway.

The cell does not actually store the charging current for the entire duration of the charge cycle. At the start and end of the charge period energy provided by the charging current is used to reconstitute the electrodes and in the production of gas. For this reason, the amount of current supplied during the charge cycle must be greater than the nominal capacity of the cell. A charge factor of 1.4 is used, i.e. the cell must be provided with 1.4 of its nominal capacity to reach the fully charged state. Thus with a normal charging current of C5/10 we arrive at a charge time of 14 hours.

If the nominal charge time is exceeded, the cell starts to overcharge, i.e. it ceases to store the charge current, but rather converts it into heat. Providing this occurs with the normal charging current and the cell temperature remains within the limits prescribed by the manufacturer, nicad cells are capable of withstanding long term overcharging. Depending upon the manufacturer and type of cell, the minimum temperature for normal charging is between 0 and 10°C, whilst the maximum is between 40 and 60°C. Optimum performance is obtained between 10 and 25°C. Within this range it is possible to charge the cell to 100% of its nominal capacity. At lower temperatures the capacity of the cell starts to fall so that it takes less time to become fully charged, and the cell is less able to withstand overcharging. At higher temperatures, the

79074 - 3

79074 - 4

79074 - 5

4

U (V) vs Duration of discharge (h)

standard dry battery — high power dry battery — zinc-carbon

standard sintered nicad cell 1,65 Ah

1,1-V- discharge

0,8-V- discharge

manganese-alkali dry battery

79074 - 1
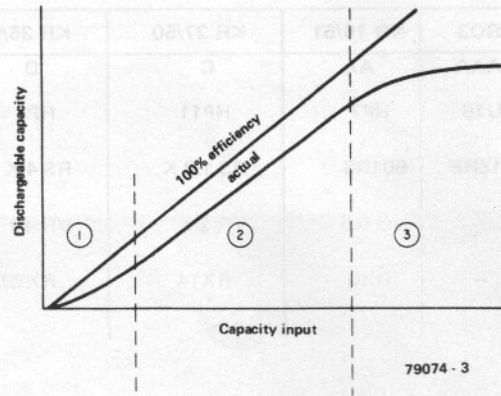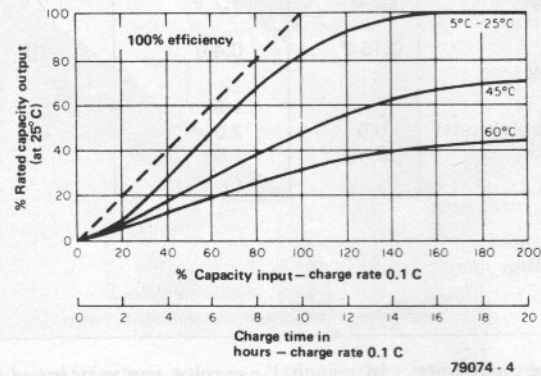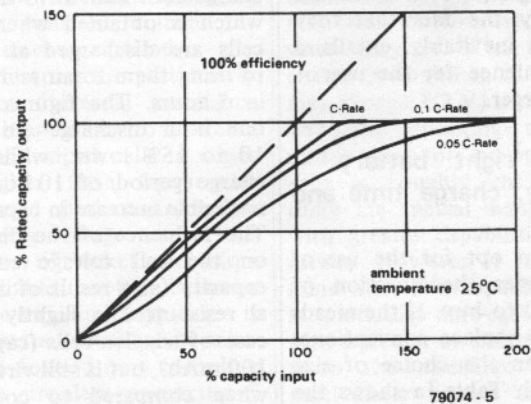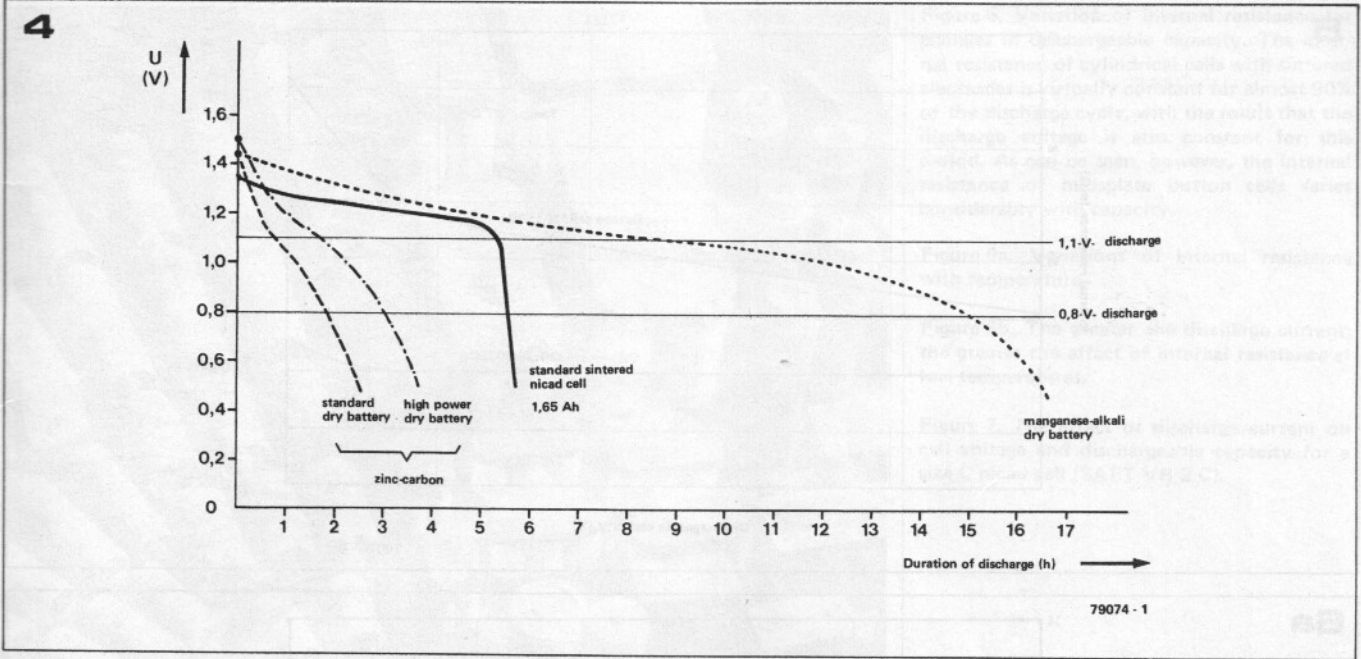
charge acceptance of the cell sinks even further; at around 55°C it falls by some 30%. The more often it is charged at high temperatures, the greater the danger of permanent damage to the cell.

It is important to check the manufacturer's specifications regarding overcharging of cells with the normal charging current, since the maximum permissible length of time varies. For example one manufacturer quotes 20,000 hours as being acceptable, a second draws the line at 500 hours, whilst a third is more cautious and states that occasionally overcharging for up to several days should have no untoward consequences. The last remark is valid for all types of nicads, although no harm is done if the charge cycle is ended once the cell is fully charged.

Charging the cell with a current lower than the normal charge current is possible, but there are a couple of drawbacks. The charge factor of the cell rises to around 2, whilst repeated charging at lower than recommended currents can cause a temporary reduction in the effective capacity of the cell. A charge current of less than half the prescribed value should not be used for regular recharging of cells which are completely exhausted. It is possible to use smaller currents to recharge partially discharged cells, although again there is a loss of capacity due to the so-called 'memory' effect. The cell as it were notices that it is not being fully charged and adapts accordingly. This effect is also caused by repeated charging at high temperatures. The lost capacity can normally be restored by several charge cycles with 'full' current, the cell being discharged fairly rapidly between each cycle.

Overcharge

If a cell is required to be kept fully

Figure 1. Charge acceptance of a nicad cell. At the start and end of the charge cycle only a portion of the charge current is stored by the cell (sections 1 and 3). During overcharge almost all of the energy input to the cell is either consumed in the production of gas or converted into heat.

Figure 2. The greater the temperature, the lower the charge acceptance of a nicad cell, hence the need for slightly higher charge rates. Care should, however be taken to avoid overcharging.

Figure 3. Charge acceptance is better at high rates of charge. As the charge current decreases, so the amount of overcharge required to regain full capacity increases.

Figure 4. Comparisons of the discharge voltage characteristics of nicads and conventional dry cells. The discharge conditions represented in this graph (i.e. continuous discharge at a fairly high constant current) are extremely disadvantageous for normal zinc-carbon cells. With intermittent discharge (i.e. the cell is given time to recuperate between discharge periods) and a smaller discharge current, standard zinc-carbon cells will provide roughly the same capacity as nicad cells of equivalent size, whilst special high power zinc-carbon cells can achieve approximately twice the capacity of nicads. The capacity of manganese-alkali cells on the other hand are less dependent upon the discharge conditions.

charged (and is regularly discharged completely) then it is possible to leave the cell on *continuous* charge at a current equal to or just a little below the normal value. If the cell is used in a standby mode, however, so that it discharges only rarely and then not completely, it is recommended that, once fully charged, the current be reduced to a holding value of between 20 and 50% of the normal charging current.

Fast charging

Fast charging, using a current above the prescribed normal charging current, is possible with most types of nicads, however once again opinions differ among manufacturers.

Generally speaking, it is acceptable to fast charge fully discharged cells at rates of two to three times the normal charging current for periods of several hours — with the proviso that the temperature is greater than 20°C and not more than roughly 45°C. At temperatures lower than this the normal charging current should under no circumstances be exceeded.

Fast charging should not be undertaken without a charger with a timer or temperature sensor to automatically terminate charge or reduce it to safe levels. Obviously the use of a timer as control element requires that the initial state of the cell is known (in practice this usually means complete discharge). To take an example, fast charging a standard nicad cell at double the normal charging current is only permissible providing the temperature is not less than 20°C and the charge cycle does not exceed 6 hours. An exception to the rule, however, are the standard nicad cells from SAFT (all the cells of the VR-series, with the exception of the VR 10), which can be charged at three times the normal current for up to 10 days.

5

Internal resistance (mΩ) vs Dischargeable capacity (%)

Temp.: 20°C

Button cell: N-150B

Cylindrical cell: N-600SC

79074 - 6

6a

Internal resistance (mΩ) vs Cell temperature (°C)

Fully charged condition

79074 - 7a

6b

Capacity variation between − 40°C and + 50°C for different discharge currents

% Rated capacity

0.1 C_5 A
0.2 C_5 A
C_5 A

Discharge temperature (°C)
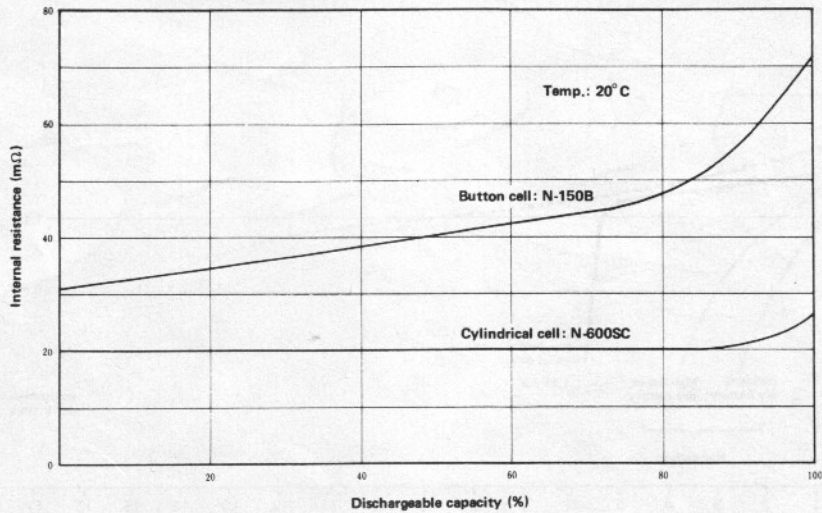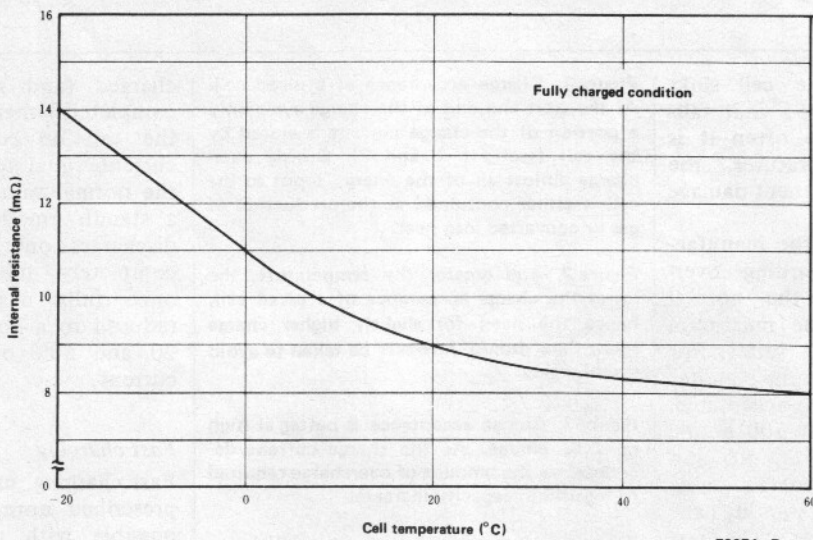
79074 - 7b
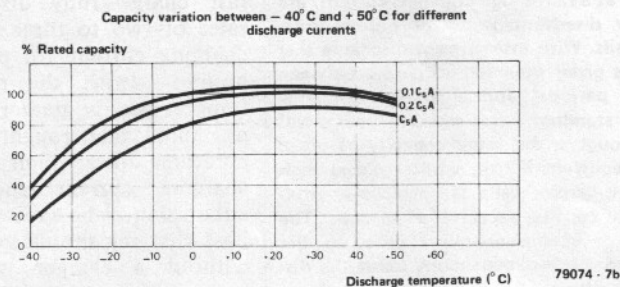
Most sintered nicad cells can be fast charged at rates even greater than those mentioned above (depending upon the type and manufacturer), however cells cannot normally be fully charged under these conditions and the same precautions must be taken to prevent overcharging and overheating. For example, an AA-cell (nominal capacity 450 mAh) which has been completely discharged, is fast charged for 45 minutes at 10 times the nominal charging current (450 mA) and then topped up at the normal current (45 mA). Over-

charging at the normal rate is then possible.

Discharge cycle

Again depending upon the manufacturer, nicads can be discharged over a temperature range of between roughly −40 to −20°C and +45 to +60°C. The nominal capacity of a cell is stated for a temperature of 20°C. At higher temperatures the effective capacity of the cell rises marginally, whilst at lower temperatures there is a significant

reduction. At 0°C the capacity may be between 5 and 25% down on the nominal value.

The internal resistance of the cell exhibits a negative temperature coefficient. As the temperature falls the internal resistance rises considerably (e.g. by as much as 75% over a temperature range of +60°C to −20°C). The increased internal resistance naturally causes a drop in the cell voltage under low temperature discharge conditions.

Because of internal resistance, the capacity of the cell is also affected by

7

Discharged at 20°C ± 5°C
Max. permissible continuous discharge current: 14.4 A

Cell voltage — Voltage and capacity variation for different discharge rates

$0.2 C_5 A = 0.4A$
$C_5 A = 2A$
$5 C_5 A = 10A$
$7 C_5 A = 14A$

Discharged capacity in Ah
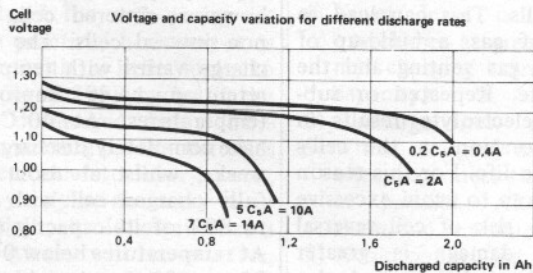
79074 - 8

the discharge rate — the greater the discharge current the smaller the capacity. The relationship between capacity and discharge rate (i.e. how much the capacity falls for a given increase in discharge current) is determined by the cell's internal resistance, which in turn is largely determined by the size and physical construction of the cell. As far as construction is concerned, a basic distinction can be made between sintered and non-sintered cells. Almost all nicad cells intended to replace conventional cylindrical batteries are

of the sintered-electrode type, whilst in the case of so-called 'massplate' button cells and 9 V battery packs (which in fact are built up of button cells) non-sintered cells are the norm. The internal resistance of sintered cells is on average something between a quarter and a tenth that of non-sintered types, and remains constant over virtually the entire discharge cycle. The internal resistance of non-sintered cells, however, rises to between 3 and 5 times its original value. Non-sintered types do have one slight advan-

tage, in that they have a lower self discharge rate — more of this later. Irrespective of the construction of cell, it is a general rule that the larger the cell (i.e. the greater the capacity of the cell), the smaller the internal resistance. However different manufacturers often state different internal resistances for cells of identical dimensions and capacity! Thus for size AA cells, one finds internal resistances of between 15 and 35 mΩ (milliohms), for C cells values between 10 and 20 mΩ, and for D type cells resistances around 5 to

Cutaway view
of VR 4 D cell

1. Positive connections

2. Cover

3. Central button (positive)

4. Safety Vent

5. Positive plate

6. Separator

7. Negative plate

8. Nickel-plated steel case

9. Negative connection

79074 - 2

Figure 8. Construction of a cylindrical nickel-cadmium cell with sintered electrodes. The case is hermetically sealed, however a resealing safety vent on the top cover of the cell enables gas which has built up due to excessive charge or discharge rates to be released, thereby preventing the cell from rupturing. Repeated venting will result in a loss of electrolyte and permanent degradation in the cell's performance.

Figure 9. Cell voltage characteristic during cell reversal. Excessive reverse charge (where e.g. large numbers of cells are connected in series) can result in permanent damage to the cell.

Figure 10. Self discharge rates of massplate button cells (top) and sintered cells (bottom) for different temperatures. As can be seen, the nonsintered cells have the better charge retention characteristics.

15 mΩ. A good quality manganese-alkali cell will have an internal resistance of approximately 300 mΩ when new, rising to around 900 mΩ when 20% discharged and several ohms when almost exhausted.

For the majority of applications the internal resistance of nicad cells can to all intents and purposes be disregarded, since it is several hundred percent smaller than that of conventional dry cells. However in cases where extremely high discharge rates are required, such as the powering of radio controlled model planes and ships, the effect of the internal resistance on discharge current and cell capacity must be taken into account. For example, if a cell is discharged at a rate of four times its nominal capacity (e.g. at 4 A in the case of a 1 Ah cell), the effective capacity of the cell is reduced by approx. 30%. The maximum permissible continuous discharge current is determined by the amount of heat generated in the cell, and, depending upon the type of cell and the manufacturer, is somewhere between 4 and 10 times the nominal capacity. With adequate ventilation or if the cell is being operated in a pulsed mode, considerably higher discharge rates are possible — up to 150 times the nominal capacity in the case of certain button cells. For such specialised applications, however, one should always carefully observe the manufacturer's specifications on the cell, and if in any doubt

seek advice from the company's engineers.

For all applications the behaviour of nicads when fully discharged is worth attention. When several nicads are connected in series (i.e. whenever a supply voltage of greater than 1.2 V is required), it can happen that one cell discharges before the rest. In such a case it is possible that the polarity of the cell is reversed and is then effectively charged the 'wrong way round' by the remaining cells. This can lead to the production of gas, a build-up of internal pressure, gas venting and the lose of electrolyte. Repeated or substantial loss of electrolyte results in permanent deterioration in the cell's capacity and cycle life. For this reason care should be taken to avoid excessive discharching. The risk of cell reversal and consequent damage is greater under heavy load conditions and also when larger numbers of cells are connected in series.

As a result of both heat production and polarity reversal (in series connections), cells can be permanently damaged through short circuits. If the short occurs externally, i.e. in the circuit which the cell is powering, the resulting extremely high current may cause considerable damage on sensitive components or on the tracks p.c.b., not to mention the risk of personal injury. It should be remembered that the top cover and shell of the case are connected directly to the electrodes of the cell and it is almost

always advisable to take the precaution of including a safety fuse in the live lead of the supply.

Shelf life and charge retention

Nicad cells can be stored virtually indefinitely in any state of charge at ambient temperatures between approximately −40°C and +50°C. Fully or partially charged cells gradually lose capacity as a result of self-discharge however; sintered cells more so than non-sintered cells. The rate of self-discharge varies with temperature, charge retention being improved at lower temperatures. At 40°C the cell will have completely discharged within a few weeks, whilst at room temperature a fully charged cell with still deliver 60 to 80% of its capacity after 3 months. At temperatures below 0°C capacities of 80 to 90% can be obtained even after several months. Because of the effect of different storage temperatures and times it is normally not possible for the buyer of nicad cells to know what state of charge new cells will be in. For this reason one should always fully recharge new cells before they are put into service.

Expected life

As long as they are not subjected to abusive treatment, nicad cells can be charged and discharged upwards of 500 times. As the number of cycles increases,

9

79074 - 9

10a

79074 - 10a

10b
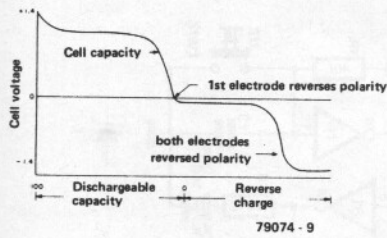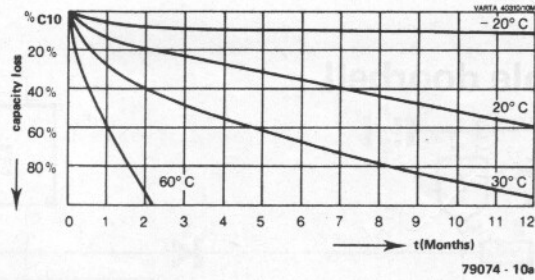
79074 - 10b
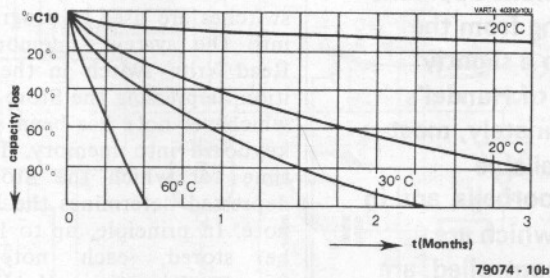
there is a gradual loss of capacity. It is considered that the useful life of the cell has ended when its capacity has dropped to around 70 to 80% of its nominal capacity. When this point is reached will depend upon the average ambient operating temperature (high temperatures shorten a cell's life) and the average depth of discharge.

Although incomplete discharging increases the cycle life of the cell, it should not significantly affect the total energy output of the cell during its useful life. In practice, however, it is often possible, with a little luck, to reach 1500 or even 2000 cycles if the cell is never discharged below 50% capacity. Thus recharging the batteries in one's pocket calculator every week, although it may only be necessary to do so every fortnight, could mean that a single set of batteries will last not five, but seven to ten years. On the other hand, radio modellers using nicads at high rates of discharge and then fast recharging them from a car battery cannot reckon with cycle lives much over 100. In other words, the useful life of nicad cells varies considerably with the operating conditions and recharge rates.

Precautions to ensure a long operating life

1) Never solder direct to the terminals of the battery (unless solder tags are provided)
2) Take care when charging cells at low

temperatures. Cells which are used out of doors during the winter should first be warmed to room temperature before being recharged. Avoid charging and discharging at high temperatures, and under no circumstances exceed the prescribed temperature range.
3) At all costs avoid short circuits and over-discharging at high current rates. In general completely discharging cells should be avoided.
4) Never leave cells on continuous overcharge at greater than their normal charging current (1/10 nominal capacity).
5) Recharge new cells before use.
6) When charging a number of cells, always connect them in series, *never in parallel*. Alternatively, charge them one at a time.
7) Avoid connecting the cells the wrong way round (reversed polarity) when charging or discharging.
8) *Never* open or throw nicad cells into the fire. Take care if cells are physically damaged — cadmium is toxic and the electrolyte in the cell is highly corrosive.
9) Take note of the manufacturer's recommendations.

Hopefully, the above article has succeeded in shedding a little light on the topic of nicad cells, and has shown that there are many applications where their high rates of charge and discharge, allied to their ability to be used again and

again, make them a highly attractive proposition.

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elekdoorbell

Programmable doorbell

Gone are the days of the simple 'ding-dong' doorbell ('Avon calling . . .'). Many modern house-holders seem to want doorbells that play anything from the 1812 Overture to a slightly abridged version of Handel's Messiah. Unfortunately, most commercially available programmable doorbells, and in particular those which are microprocessor-controlled, are anything but cheap (£ 20 is not uncommon). For this reason we decided it would be nice to design a programmable doorbell which could be built for around a fiver. The result of our efforts — the 'Elekdoorbell' — is capable of playing almost any desired tune up to 128 notes in length. The circuit can be mounted on a single board, and the current consumption is extremely low, so that an existing bell transformer can be used for the power supply.

The block diagram of the Elekdoorbell is shown in figure 1. At the heart of the circuit is an 8-key keyboard, by means of which the notes of each tune are selected. The Read/Write and Store switches are used to program the notes into the system's memory. With the Read/Write switch in the 'Write' position, depressing the Store switch writes whichever note has been set up on the keyboard into memory. The length of time for which the Store switch is depressed determines the length of the note. In principle, up to 128 notes can be stored, each note occupying 8 memory locations. Holding the Store switch down for longer causes the note to occupy successive multiples of 8 memory locations. The number of possible notes which can be stored is of course then reduced accordingly.

Assuming that a tune has already been stored in the system's memory and that the Read/Write switch is in the 'Read' position, depressing the Start button (which will normally be mounted outside the front door) causes a flip-flop to change state. This resets a 12-bit counter which serves as an address decoder. The clock generator now clocks the address decoder through the various memory locations; the contents are transferred to a serial-parallel converter. The parallel information is

fed to a digital-analogue converter which provides a current proportional to the binary value of the contents of each memory location. This current in turn determines the frequency of the audio oscillator. The last output of the address decoder is used to reset the flip-flop, preventing the tune from being repeated. The output of the oscillator must be fed to a separate audio amplifier, preferably provided with a volume control.

The flip-flop also controls an LED, which lights whenever the Start button is depressed. In this way it is possible to turn 'off' the doorbell (by turning down the volume of the audio amplifier) and still retain an indication when someone is at the door.

Figure 1. Block diagram of the Elekdoorbell.

Figure 2. Complete circuit diagram of the Elekdoorbell. Although the circuit may at first sight appear complicated, in fact it employs relatively few components and should cost little to build.

2

I1 . . . I6 = IC1 = 4049
N1 . . . N4 = IC2 = 4093
N5, N6 = IC3 = 4012
FF1, FF2 = IC9 = 4013
D4 . . . D16, D18 = DUS

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3

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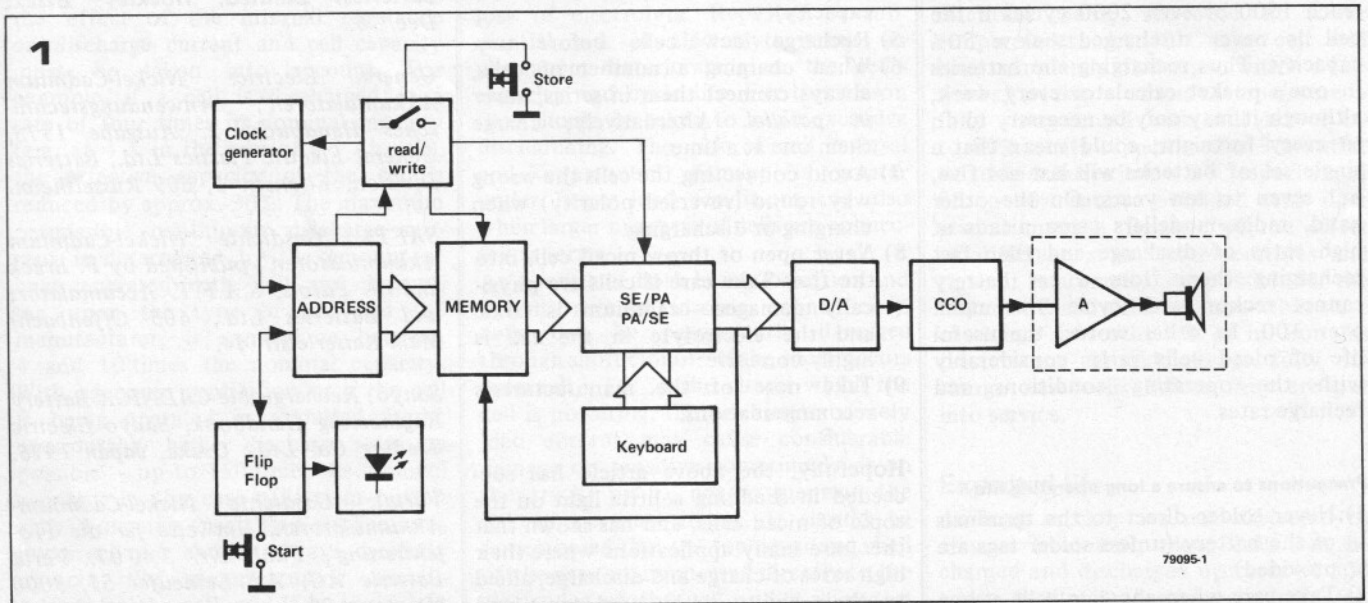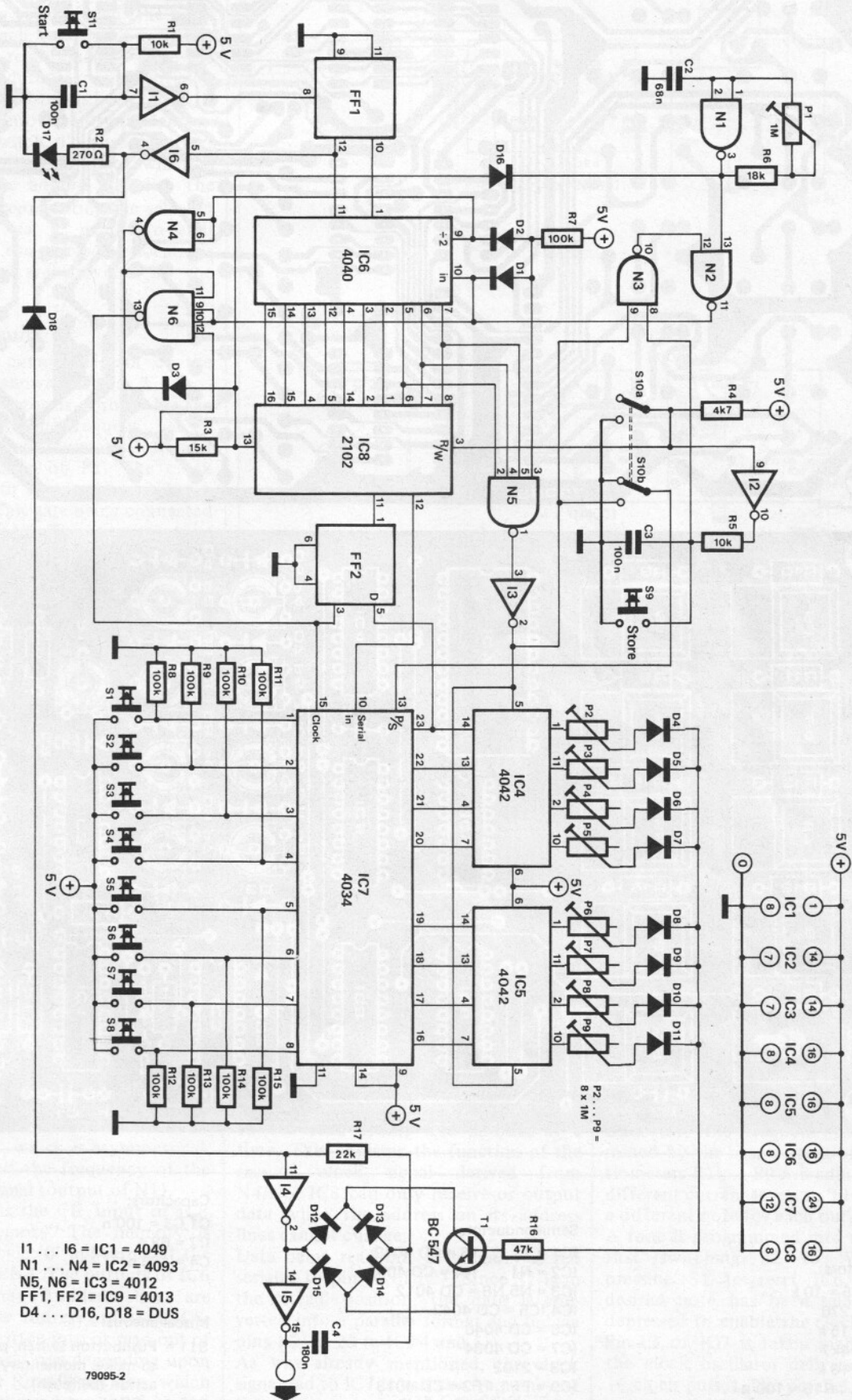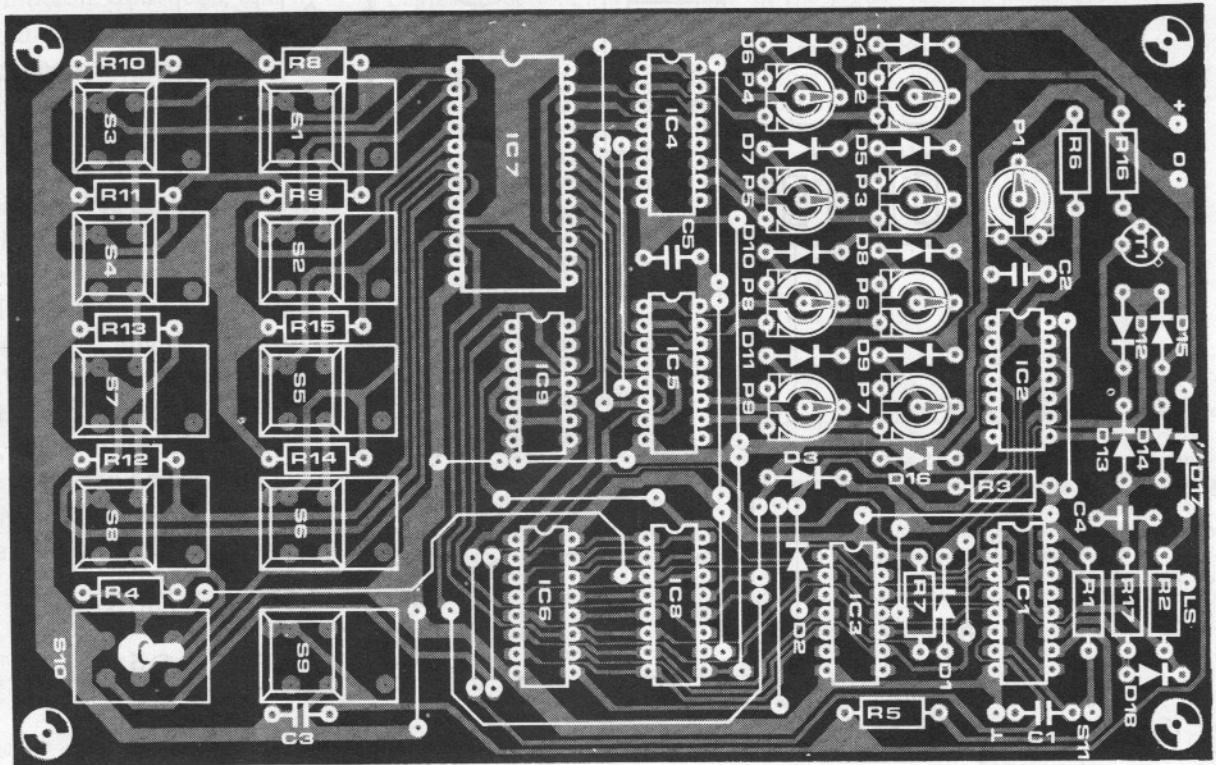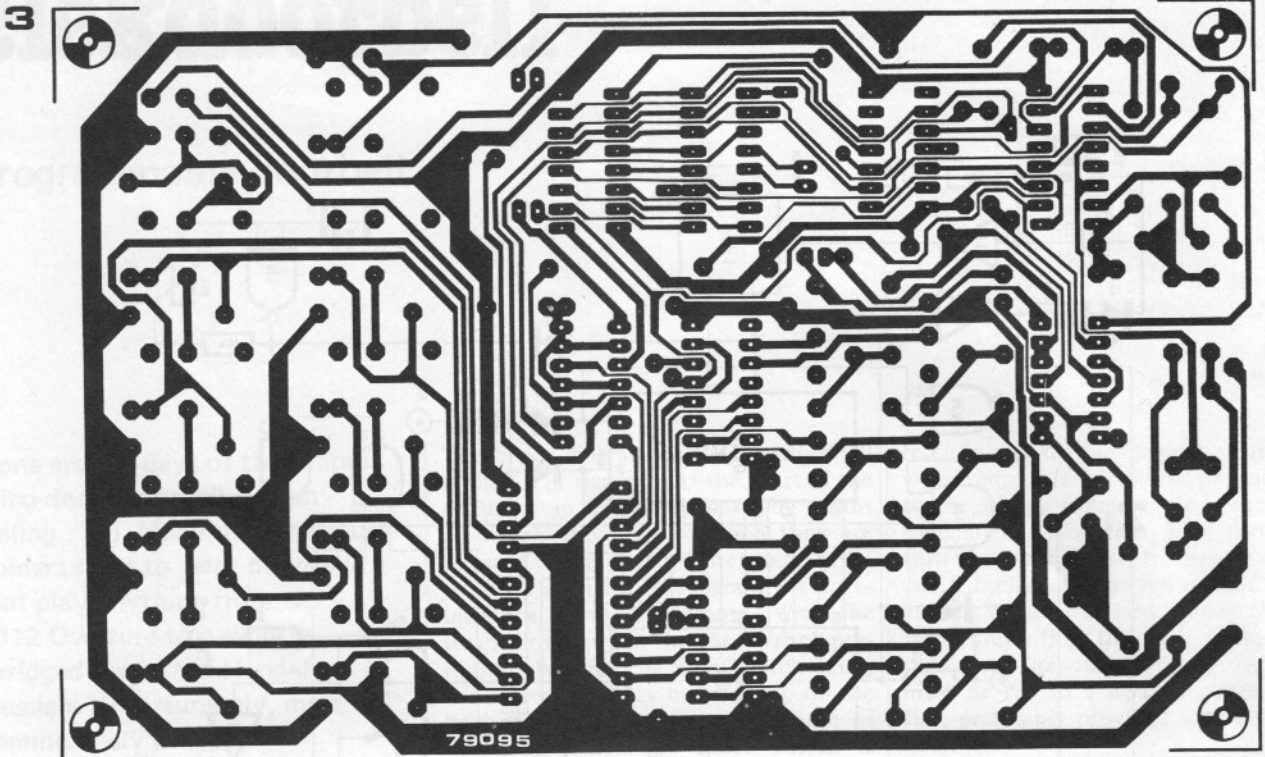
Parts list.

Resistors:
R1,R5 = 10 k
R2 = 270
R3 = 15 k
R4 = 4k7
R6 = 18 k
R7 . . . R15 = 100 k
R16 = 47 k
R17 = 22 k
P1 . . . P9 = 1 M

Semiconductors:
IC1 = 11 . . . 16 = CD 4049
IC2 = N1 . . . N4 = CD 4093
IC3 = N5,N6 = CD 4012
IC4,IC5 = CD 4042
IC6 = CD 4040
IC7 = CD 4034
IC8 = 2102
IC9 = FF1,FF2 = CD 4013
D1 . . . D16,D18 = DUS
D17 = LED
T1 = BC 547B

Capacitors:
C1,C3 = 100 n
C2 = 68 n
C4 = 180 n

Miscellaneous:
S11 = Pushbutton switch, push-
to-make, momentary
action (bellpush).
S10ab = DP changeover switch
S1 . . . S9 = 'digitast' (Schadow)
pushbutton switch.

To store a tune in memory, the Read/Write switch is set to the 'Write' position and the Start button depressed. The initial note of the melody is then selected from the keyboard. If no one key provides the desired pitch, combinations of keys can be tried (the pitch produced by each key can be varied to suit individual requirements — see the setting up procedure later in the article). Once the correct note has been found, it is programmed into memory by depressing the Store switch. This has the effect of starting the clock oscillator, which in turn enables the address decoder. The keyboard data representing the selected note is fed, via a parallel-to-serial converter, to the memory locations whose addresses are provided by the address decoder.

Complete circuit

The complete circuit diagram of the Elekdoorbell is shown in figure 2.

The clock generator is formed by the circuit round N1. The frequency can be varied between approximately 30 and 100 Hz by means of P1. The clock pulses are fed to one input of N2, the other input of this gate being connected to the output of N3. The output state of N3 is determined by the position of the Read/Write switch, S2, and by the Store switch, S3. When S2 is in the 'Write' position the number of clock pulses fed out via N2 is limited to 16 via N5 and I3. When the output of IC6 (a 12-bit binary counter) reaches 16, the output of N5 goes low, taking the output of I3 high.

Eight memory locations, and hence eight addresses are required for each note. This corresponds to 16 clock pulses, since two are required for each address. If the Store switch is depressed for a longer period (with a clock frequency of 30 Hz, holding the switch down for greater than 0.5 sec.) more than one clock cycle will be generated, lengthening the note by a corresponding amount.

The clock signal is also fed via a divide-by-two counter in IC6 to N4, whilst the direct clock signal from N2 is fed to N6. The pulse train which is generated at the output of N6, and which is used to clock an 8-bit bus register (IC7), is shifted in time with respect to the clock signal fed to IC6.

The pulse train, which is asymmetrical, actually has half the frequency of the original clock signal (output of N1).

N1 also controls the $\overline{CE}$ input of IC8, the system memory. The memory is enabled by a logic '0' appearing at the output of N1 or N4. The outputs of IC6 which form the 10 address lines are connected to the address inputs of IC8. Data is either written into or read out of these address locations depending upon the state of the Read/Write line, which in turn is of course determined by the state of S2. Data is read out of IC8 via pin 12, and into IC8 via pin 11. Since this can only occur when the clock
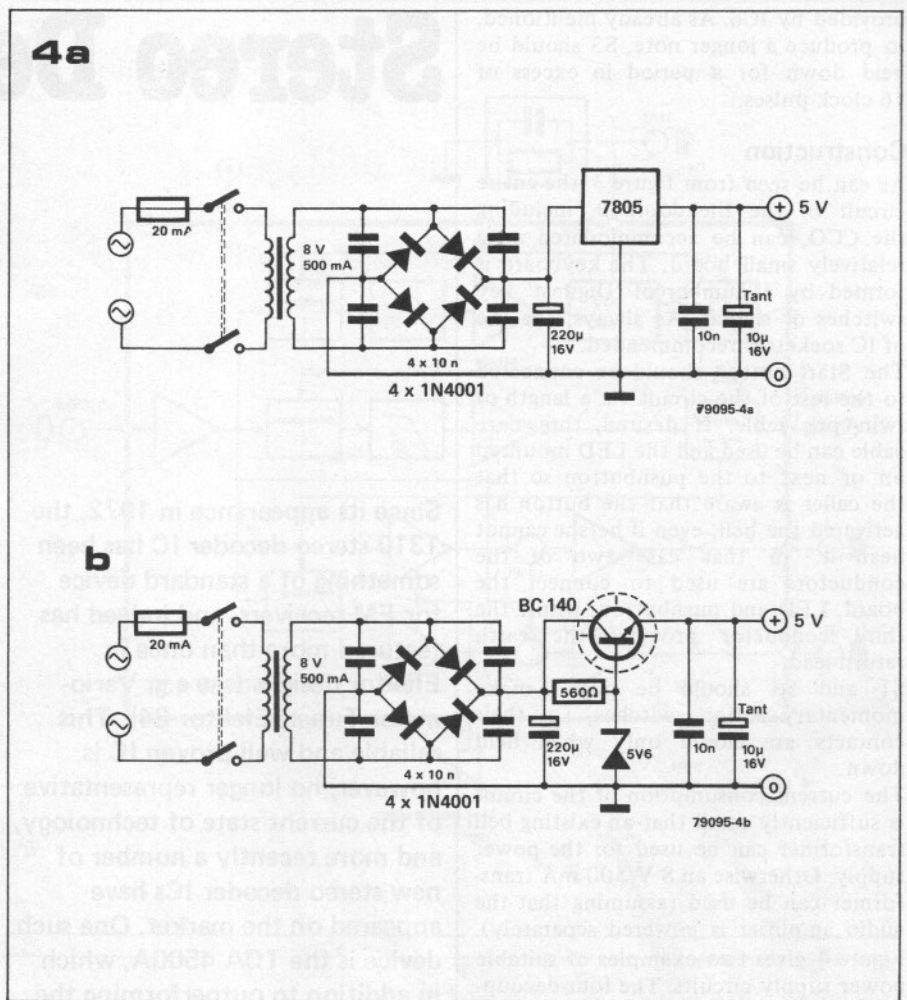
Figure 3. Track pattern and component layout of the printed circuit board for the Elekdoorbell (EPS 79095).

Figure 4. Two examples of suitable power supply circuits.

signal is low, data can only be written to (or read from) one address at a time. This explains the function of the second clock signal derived from N4/N6. IC8 can only receive or output data when the address on its address lines cannot change.

Data being read out of memory is fed serially to pin 10 of IC7. Since S2 is in the 'Read' position, the data is converted into a parallel format and fed via pins 16 . . . 23 to ICs 4 and 5.

As was already mentioned, the clock signal fed to IC7 is half the frequency of the original clock signal from N1. The reason for this is that IC6 requires two clock pulses to generate each new address.

Since the divided-by-two clock signal is also delayed with respect to the first 'address' clock pulse, there is no possibility of an undefined address existing when the first bit of data is read out or in.

ICs 4 and 5 form a 'scratch-pad' memory, on which the data from IC7 can be temporarily stored. The outputs of IC4 and 5 are normally low, except of course for the output corresponding to the note stored in memory (if several keys were depressed in order to obtain a special note, then more than one output will be high). A logic '1' on the output of IC4 or 5 causes a current to flow, via the corresponding diode and potentiometer, into the base of T1. This transistor, together with D12 . . . D15, 14 and 15 forms a current controlled oscillator, the frequency being determined by the base current of T1. Potentiometers P2 . . . P9 are adjusted to pass different current levels to T1 to produce a different note for each output.

A tune is programmed into memory by first switching S2 to 'Write', and pressing S1 to reset IC6. Once the desired note has been selected, S3 is depressed to enable the clock oscillator. Pin 13 of IC7 is taken high each time the clock oscillator delivers a cycle of 16 clock pulses. The parallel data on the outputs of IC7 is then shifted in serial form to pin 23, transferred via FF2 to the data input of IC8, and stored in the memory location whose address is

provided by IC6. As already mentioned, to produce a longer note, S3 should be held down for a period in excess of 16 clock pulses.

Construction

As can be seen from figure 3, the entire circuit of the Elekdoorbell, including the CCO, can be accommodated on a relatively small board. The keyboard is formed by a number of 'Digitast' key switches or similar. As always, the use of IC sockets is recommended.

The Start button should be connected to the rest of the circuit via a length of twin-core cable. If desired, three-core cable can be used and the LED mounted on or next to the pushbutton so that the caller is aware that the button has activated the bell, even if he/she cannot hear it. In that case two of the conductors are used to connect the board, LED and pushbutton, whilst the third conductor provides the earth return lead.

S1 and S3 should be push-to-make momentary action switches, i.e. their contacts are closed only when held down.

The current consumption of the circuit is sufficiently small that an existing bell transformer can be used for the power supply. Otherwise an 8 V/500 mA transformer can be used (assuming that the audio amplifier is powered separately). Figure 4 gives two examples of suitable power supply circuits. The four decoupling capacitors are not always strictly necessary, but serve to prevent interference from mains-switched equipment (fridges etc.) causing unnecessary trips to the door.

Setting up/Programming the Elekdoorbell

Once the circuit is constructed, the keyboard can be 'tuned' to the desired scale and a tune programmed as follows:

1. Switch S2 to the 'Write' position
2. Press the Start button (once).
3. Depress S4 and gradually adjust P2 until a tone is obtained which corresponds to the lowest note in the tune/scale.
4. Repeat the above procedure for switches S5 ... S11 and potentiometers P3 ... P9, until the desired scale of notes is obtained (e.g. the tempered tonic scale of doh, re, mi, fa, etc.).
5. Turn P1 fully anticlockwise (minimum clock frequency).
6. Play through all the notes of the tune to be programmed, pressing S3 between each note. The longer S3 is held down, the longer the note.
7. Switch S2 to 'Read'.
8. Press the Start button.
9. Check whether the melody is correct, and adjust the clock frequency to obtain the desired tempo.
10. Ensure that the supply voltage is not interrupted, otherwise the tune will be reprogrammed. ◄

Stereo Decoder

Since its appearance in 1972, the 1310 stereo decoder IC has been something of a standard device for FM receivers, and indeed has featured more than once in Elektor designs (see e.g. Variometer Tuner, Elektor 24). This reliable and well-proven IC is, however, no longer representative of the current state of technology, and more recently a number of new stereo decoder ICs have appeared on the market. One such device is the TCA 4500A, which in addition to outperforming the 1310 on virtually every count, offers one or two novel features such as continuously adjustable channel separation. This article describes a practical circuit for a stereo decoder incorporating the TCA 4500A, for which (as ever!) a printed circuit board is also available to facilitate construction. The circuit is also compatible with the IF strip published in this issue, so that, with the addition of a suitable quality front-end, one has all the ingredients for a high performance FM tuner.

The block diagram of the decoder circuit is shown in figure 1. The multiplex encoded (MPX) stereo signal is fed via an input buffer amplifier to the TCA 4500A, which forms the heart of the circuit. The IC provides the left and right channel audio signals, which are amplified and fed to a twin-notch filter which eliminates residual traces of the 19 kHz pilot tone and the 38 kHz subcarrier. Although these frequencies are themselves inaudible, they can give rise to intermodulation distortion in the amplifier, or worse still, when used in conjunction with a tape recorder, the 38 kHz subcarrier can beat with the bias oscillator, producing distinctly unpleasant results. The pilot tone filter is followed by a low impedance output buffer amplifier, which ensures that the audio signals are of acceptable level.

TCA 4500A

The internal block diagram of the TCA 4500A is shown in figure 2. The multiplexed stereo signal is first amplified, then fed to a 19 kHz phase-locked loop detector (1) which controls the frequency of the VCO. The detector is essentially a phase comparator, the output voltage of which is zero if the phase shift between the transmitted pilot frequency and the internally generated 19 kHz signal is 90°. In all other cases the discriminator provides an output with a DC component which is filtered out by the lowpass filter and used to control the frequency of the VCO such that the phase shift difference will tend to 90°.

1

MPX ▷○— [amplifier] — TCA 4500A — [amplifiers] — [19 38kHz filter] — L, R

separation

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79082-1
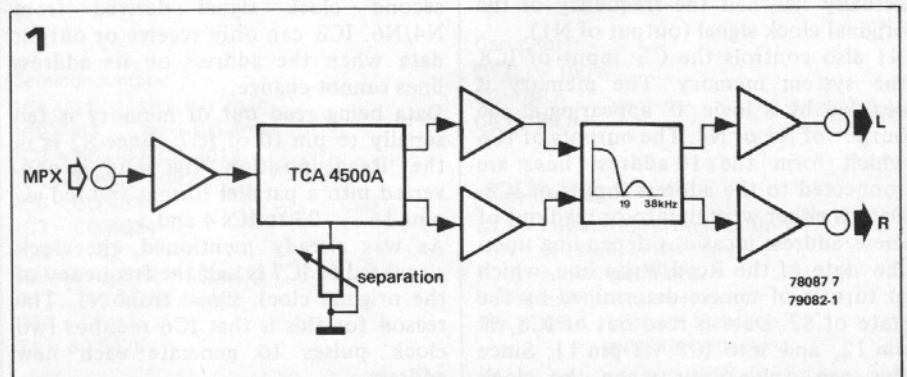
Figure 1. Block diagram of the stereo decoder circuit.

Figure 2. Internal block diagram of the TCA 4500A stereo decoder IC.

Figure 3. The 19 kHz pilot tone and 38 kHz subcarrier regenerated in the stereo decoder are not, as is usually the case, symmetrical squarewaves, but 'two-step' staircase waveforms, as shown here. The advantage of this type of waveform is that it contains a relatively small proportion of harmonics.

The VCO frequency is in fact locked to the 12th harmonic of the pilot tone, i.e. 228 kHz. The frequency of the VCO output is divided by a factor of 6 to obtain the 38 kHz subcarrier (which was suppressed at the transmitter).This is required to demodulate the original audio information. Subsequent frequency division by a factor of two provides the 19 kHz PLL feedback signal to detector 1 and a second 19 kHz signal which is fed to the pilot tone detector (2). The latter determines the presence or absence of the pilot tone in the MPX stereo signal. The 19 kHz signal is not, as is usually the case, a symmetrical squarewave, but rather a 'two-step' staircase, which represents an approximation to a sinewave (see figure 3). The advantage of such a waveform is that it contains fewer harmonics.

If the 19 kHz pilot tone is present in the MPX signal, the output of detector 2 provides a drive voltage for the Schmitt trigger which controls the stereo switch (and stereo indicator lamp). The switch then feeds the re-generated 38 kHz subcarrier to detector 3, which demodulates the left and right channel audio signals. These are buffered before being summed with the MPX input signal. The summing ratio is determined by the position of potentiometer P, which thus determines the channel separation of the resultant stereo signal. Finally, both the left and right channel signals are also buffered to provide a low output impedance (100 Ω).

The main specifications of the TCA 4500A are summarised in table 1.
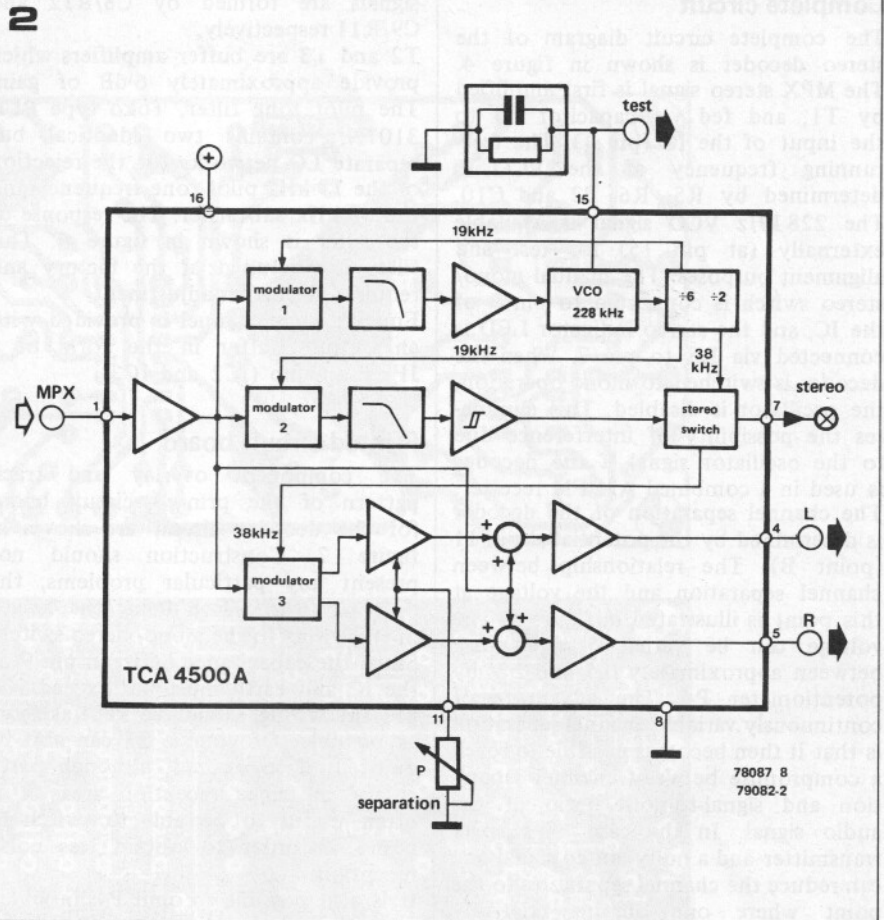
Table 1. Main specifications of the TCA 4500A

Maximum Ratings

supply voltage	16 V
dissipation	1.8 W
lamp voltage	30 V
lamp current	100 mA

Characteristics (U_b = 12 V, T_{amb} = 25°C)

	min	typ	max	unit
channel separation (unadjusted)	30			dB
channel separation (adjusted)	40			dB
voltage gain mono	0.8	1	1.2	
total harmonic distortion				
input voltage 2.5 V_{pp}			0.3	%
input voltage 1.5 V_{pp}		0.2		%
S/N ratio		85		dB
19 kHz output		−31		dB
38 kHz output		−50		dB
76 kHz output		−45		dB
114 kHz output		−50		dB
152 kHz output		−50		dB
auto mono/stereo switch level	12	16	20	mV
hysteresis		6		dB
transient level at power on/off		5	20	mV
difference in channel strength with mono			0.3	dB
ripple rejection of supply voltage		50		dB
input impedance		50		kΩ
output impedance		100		Ω
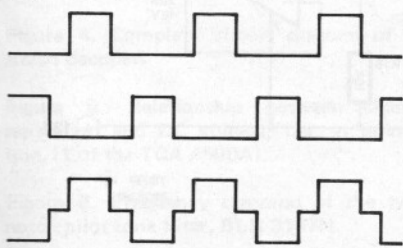
Complete circuit

The complete circuit diagram of the stereo decoder is shown in figure 4. The MPX stereo signal is first amplified by T1, and fed via capacitor C3 to the input of the IC (pin 1). The free-running frequency of the VCO is determined by R5, R6, P2 and C10. The 228 kHz VCO signal is available externally (at pin 15) for test and alignment purposes. The manual mono/stereo switch is connected to pin 9 of the IC, and the stereo indicator LED is connected via R8 to pin 7. When the decoder is switched to mono operation, the oscillator is disabled. This eliminates the possibility of interference due to the oscillator signal if the decoder is used in a combined AM/FM receiver. The channel separation of the decoder is determined by the potential at pin 11 (point B). The relationship between channel separation and the voltage at this point is illustrated in figure 5. The voltage can be varied over a range between approximately 0.5 and 2 V by potentiometer P4. The advantage of continuously variable channel separation is that it then becomes possible to reach a compromise between channel separation and signal-to-noise ratio of the audio signal. In the case of a weak transmitter and a noisy stereo signal one can reduce the channel separation to the point where one obtains relatively noise-free reception.

The components for the lowpass filter which provides the DC control voltage for the VCO are connected between pins 13 and 14. The lowpass filter for the second detector is somewhat simpler and requires only a single external component, C6. The de-emphasis networks for the left and right channel signals are formed by C8/R12 and C9/R11 respectively.

T2 and T3 are buffer amplifiers which provide approximately 6 dB of gain. The pilot tone filter, Toko type BLR 3107N, contains two identical but separate LC networks for the rejection of the 19 kHz pilot tone frequency and the 38 kHz subcarrier. The response of the filter is shown in figure 6. This filter is pre-tuned at the factory and requires no further adjustment.

Finally, each channel is provided with an output buffer in the form of a JFET op-amp (IC2 and IC3).

Printed circuit board

The component overlay and track pattern of the printed circuit board for the decoder circuit are shown in figure 7. Construction should not present any particular problems, the only point to watch being the length of the wiring to the mono/stereo switch. Since the capacitance between pin 9 of the IC and earth must not exceed 100 pF, the wiring should be kept as short as possible. Of course, S1 can also be omitted, if so desired, although particularly in fringe reception areas it is often useful to be able to switch to mono in order to obtain less noisy reception.

It is also possible to omit P4, in which case the channel separation will be permanently at maximum.

Alignment

1. First of all the gain of T1 is increased to maximum by setting P1 for zero resistance.
2. Assuming that the IF stage of the tuner has already been aligned, tune to stereo transmission and adjust P2 until the stereo indicator lamp (D1) lights up. Generally speaking, the lamp should remain lit over a fairly wide range of setting for P2. With P2 set to the middle of this range, reduce the gain of T1 by increasing the resistance of P1 slightly, and
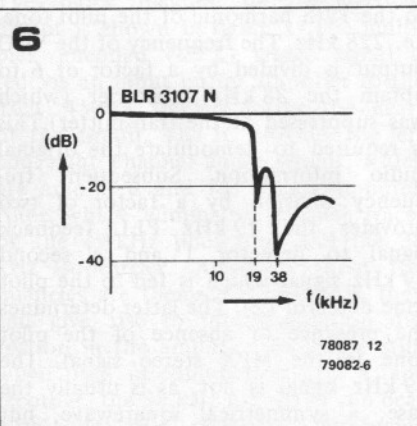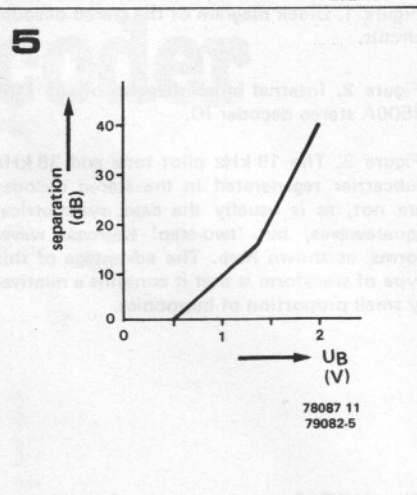
78087 11
79082-5

78087 12
79082-6

T1...T3 = BC549B

78087 10
79082-4

7

Parts list

Resistors:
R1 = 8k2
R2,R9,R10 = 56 k
R3 = 270 Ω
R4 = 2k7
R5 = 10 k
R6 = 100 Ω
R7,R21,R22 = 1 k
R8 = 680 Ω
R11,R12 = 5k6
R13,R15 = 2k2
R14,R16 = 4k7
R17 . . . R20 = 10 k

P1 = preset potentiometer, 2k2 (2k5)
P2 = preset potentiometer, 4k7 (5 k)
P3 = preset potentiometer, 10 k
P4 = linear potentiometer, 100 k

Capacitors:
C1 = 1 μ
C2 = 470 p
C3 = 1μ/40 V
C4,C6 = 220 n
C5 = 470 n
C7 = 6n8
C8,C9 = 10 n
C10 = 220 p
C11,C14 = 2μ2/40 V
C12,C13 = 22 μ/16 V
C15 = 10 μ/16 V (Tantalum)

Semiconductors:
T1. . . T3 = BC 109B, BC 549B or equ.
D1 = LED
IC1 = TCA 4500A (Motorola)
IC2,IC3 = LF 356

Miscellaneous:
F1 = BLR 3107N (Toko)
S1 = SP switch

Printed circuit board EPS 79082.

Figure 4. Complete circuit diagram of the stereo decoder.

Figure 5. Relationship between channel separation and DC voltage, U_B, at point B (pin 11 of the TCA 4500A).

Figure 6. Frequency response of the twin-notch pilot tone filter, BLR 3107N.

Figure 7. Track pattern and component overlay of the printed circuit board for the stereo decoder (EPS 79082).

once again adjust P2 until it is roughly at the centre of the range over which D1 remains lit.

3. The above step is repeated several times, gradually increasing the resistance of P1. The range of settings of P2 over which the lamp remains lit will become increasingly smaller and may even disappear. When P1 can no longer be usefully adjusted, its resistance is reduced to the point where the AC voltage at point A is not greater than 2.5 V_{pp}. In the case of a normal FM stereo transmission, the average value of the voltage at this point will be in the region of 1 V_{pp}, i.e. 350 mV RMS. In the absence of an AC millivolt-meter, it is still possible to determine the presence of excessively large signal levels at this point by the increase in distortion in the audio signal. In case of doubt P1 can simply be set to the mid-position. Of course if one possesses a frequency meter P2 can be adjusted directly with the aid of the test output (P2 is simply adjusted until a reading of 228 kHz is obtained — the receiver is not tuned to a transmission).

The channel separation can be optimised with the aid of potentiometer P3. The adjustment is carried out with P4 set for maximum resistance. Adjusting P3 affects the crosstalk from both right to left and left to right channels, and the optimum position represents a compromise situation where there is equal crosstalk in both directions. For this adjustment in particular the test tone transmissions broadcast by the BBC — which are discussed below — are extremely useful.

◄

VHF Stereo Test Transmissions

Each Monday and Saturday evening, at the end of normal programmes, Radio 3 VHF transmitters broadcast a series of test tones which can be used to help set up and check FM receivers. A number of these test signals are useful when aligning both the IF strip and the stereo decoder published in this issue. The various test signals broadcasted are listed in table 1. All signals are sinusoidal, and are transmitted with pre-emphasis.

The fact that most of the test signals are broadcast at a constant level for at least a minute provides an excellent opportunity to accurately align the quadrature tuned circuit of the IF demodulator. As was described in the alignment procedure for the IF strip, the core of the phase quadrature coil, L2 (see figure 4), is adjusted for maximum (audio) output signal, whereupon the core of L3 (if present) is adjusted for minimum output signal level. This procedure is obviously rendered more difficult if there are variations in the amplitude of the input signal.

The first test signal is intended to identify the left and right channels and to establish the reference signal level for the subsequent test signals. In practice the 0 dB level corresponds roughly to the average signal level of a normal FM transmission.

The second test signal can be used to adjust the VCO frequency of the stereo decoder by increasing the difference signal of the two channels to a maximum. When the amplifier to which the stereo decoder is connected is switched to mono, there should in theory be no audible output. Both this signal and the next can also be used to set the input sensitivity of the stereo decoder. P1 of the decoder circuit is adjusted until the AC voltage at point A (see figure 4) is approximately 2.5 V_{pp}.

If a distortion meter is available, it is also possible to check the distortion of the tuner (one should bear in mind that the distortion level of the signal *before* it is processed by the tuner is already some 0.2%).

Test signals 4 and 5 enable the crosstalk between both channels to be monitored and then minimised by adjusting P3 of the decoder circuit.

Tests 6 and 7 are intended to check the frequency response of the two channels, and to determine the amount of crosstalk between channels at low and high frequencies.

Finally, test 8, during which only the 19 kHz pilot tone is transmitted, allows the noise level to be checked (since one is hearing nothing but noise!). It can also be used to tune the frequency of the VCO in the stereo decoder, using the procedure described in that article. Note that the 19 kHz pilot tone is transmitted during all the above-mentioned test signals.

Although the full schedule of test signals is broadcast only on Mondays and Saturdays, on other days a 250 Hz tone is transmitted in the left channel only for approximately 20 minutes after close of programmes on Radio 3. This signal can be used for channel identification and to check cross-talk.

Further information on the BBC's VHF test transmissions and FM reception can be obtained from the Engineering Information Department. BBC, Broadcasting House, London W1A 1AA.

Table 1.

Test No.	Time	Left channel	Right channel
1	T*	250 Hz at 0 dB	440 Hz at 0 dB
2	T + 2 min	900 Hz at +7 dB	900 Hz at +7 dB in in antiphase to left channel
3	T + 6 min	900 Hz at +7 dB	900 Hz at +7 dB in phase with left channel
4	T + 7 min	900 Hz at +7 dB	—
5	T + 8 min	—	900 Hz at +7 dB
6	T + 9 min 20 sec	Tone sequence at − 4 dB: 60 Hz, 900 Hz, 5 kHz, 10 kHz. Sequence is repeated	—
7	T + 10 min 20 sec	—	Tone sequence as for L channel on test 6
8	T + 11 min 20 sec	—	—

*T is approximately 4 minutes after close of Radio 3 programmes (see Radio Times)

variable logic gate

J. C. Knapp

The logic gate type MC14530 (and its equivalents) is not used very much. This 'dual, five-input majority gate' is, however, intriguing. Amongst other things, it can be used as a 'variable logic gate' as described here: by inter-connecting some of its inputs, a logic gate is obtained that will give various logic functions depending on the logic level at two 'control inputs'. This can be useful in education, as well as in micro-computers!

Figure 1 is a simplified block diagram of the MC14530. As can be seen, each of the two 'majority gates' is actually followed by an EXNOR. The output M of the majority gate is determined in a most democratic way: it is equal to the majority vote (input levels)! If three or more of the inputs A . . . E are at logic '1', the output will also be 'high'; if three or more inputs are at logic 'Ø' the output will also be 'low'. This corresponds to the Boolean equation:
M = ABC + ABD + ABE + ACD + ACE + ADE + BCD + BCE + BDE + CDE.

The function of the EXNOR at the output is simply to invert the output level, if required. As can be seen from the truth table (table 1), the output Z is equal to M if control input W is at logic '1'; otherwise it is inverted ($Z = \overline{M}$).

The 'variable logic gate' is obtained by linking two inputs A and B of the majority gate to form a common input X, and similarly linking C and D into one input Y (see figure 2). The remaining input E is used as one of the control inputs.

The complete unit now functions as shown in table 2. As can be seen, four different logic functions are determined by the logic levels on the control inputs E and W. Furthermore, if X and Y are linked to form a single input the complete gate will operate as an inverter as long as W is 'low'; with W at logic '1' a non-inverting buffer is obtained. Finally, with X and Y once again linked (forming a common input V), W and V can be used as two inputs of an EXNOR. Of course.

1

2

1/2 MC 14530

79083 2
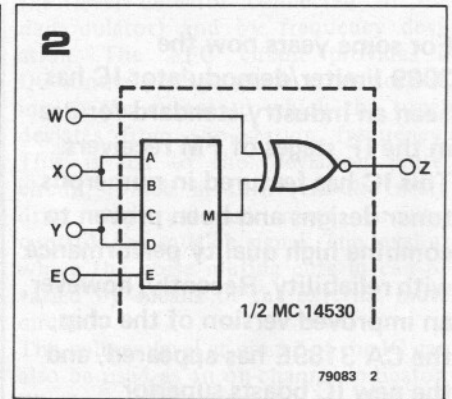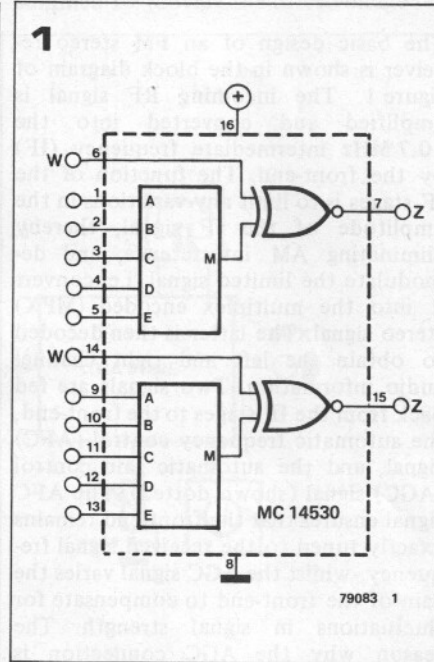
Table 1.

W	M	Z	comments
Ø	Ø	1	$Z = \overline{M}$
Ø	1	Ø	
1	Ø	Ø	$Z = M$
1	1	1	

Table 2.	control inputs		logic inputs		combined output	logic function
	E	W	X	Y	Z	
	Ø	Ø	Ø	Ø	1	
			Ø	1	1	
			1	Ø	1	NAND: $Z = \overline{X \cdot Y}$
			1	1	Ø	
	Ø	1	Ø	Ø	Ø	
			Ø	1	Ø	
			1	Ø	Ø	AND: $Z = X \cdot Y$
			1	1	1	
	1	Ø	Ø	Ø	1	
			Ø	1	Ø	
			1	Ø	Ø	NOR: $Z = \overline{X + Y}$
			1	1	Ø	
	1	1	Ø	Ø	Ø	
			Ø	1	1	
			1	Ø	1	OR: $Z = X + Y$
			1	1	1	
			V			
	x	Ø	Ø		1	NOT: $Z = \overline{V}$
			1		Ø	
	x	1	Ø		Ø	BUFFER: $Z = V$
			1		1	
	x	Ø	Ø		1	
	x	Ø	1		Ø	EXNOR: $Z = \overline{V \oplus W}$
	x	1	Ø		Ø	
	x	1	1		1	

x = Don't care.

FM IF Strip

using the CA 3189E

For some years now the 3089 limiter/demodulator IC has been an industry standard for use in the IF stages of FM receivers. This IC has featured in numerous tuner designs and been proven to combine high quality performance with reliability. Recently, however, an improved version of the chip, the CA 3189E has appeared, and the new IC boasts superior specifications and several additional facilities. This article takes a look at the new device and presents a circuit design and printed circuit board for a high-quality IF strip incorporating this 'state-of-the-art' IC. The circuit is also compatible with the stereo decoder published in this issue.

The basic design of an FM stereo receiver is shown in the block diagram of figure 1. The incoming RF signal is amplified and converted into the 10.7 MHz intermediate frequency (IF) by the front-end. The function of the IF stages is to limit any variations in the amplitude of the IF signal, thereby eliminating AM interference, and demodulate the limited signal, i.e. convert it into the multiplex encoded (MPX) stereo signal. The latter is then decoded to obtain the left and right channel audio information. Two signals are fed back from the IF stages to the front-end, the automatic frequency control (AFC) signal, and the automatic gain control (AGC) signal (shown dotted). The AFC signal ensures that the front-end remains exactly tuned to the received signal frequency, whilst the AGC signal varies the gain of the front-end to compensate for fluctuations in signal strength. The reason why the AGC connection is shown as a dotted line is that in many situations, in particular where there are two transmitters close together broadcasting signals of approximately the same strength, automatic gain control can do more harm than good. AGC is really only useful with very high performance front-ends, and even then only in certain cases (i.e. when the front-end uses a PIN diode attenuator).

Improved performance

The CA 3189E is basically similar to the 3089, however it possesses a number of advantages over its predecessor. It has a greater signal-to-noise ratio (72 dB as opposed to 67 dB) and the bandwidth has been reduced from 25 to 15 MHz,

thereby improving the stability of the circuit. The CA 3189E also offers a number of additional facilities not provided on the 3089. By providing for the use of an external audio load resistor rather than fabricating the load resistor on-chip, as is the case with the 3089, the audio output level can be varied by selecting different value resistors.

Many FM tuners incorporate an audio muting circuit, which eliminates annoying interstation noise by 'squelching' the audio signal when no transmission is being received. The squelch circuit is triggered when the audio signal falls below a certain threshold level. In addition to this type of noise muting circuit, the CA 3189E also provides 'deviation muting', the audio signal being squelched when the receiver is mis-tuned. This facility prevents those loud thumps which occur when one tunes rapidly through a station.

Finally the new IC offers one or two extra 'luxuries', such as an on-channel indicator (i.e. an output which goes low when the receiver is correctly tuned into a station), adjustable AGC, and suppression of the tuning meter voltage at very low signal levels, when the meter reading is no longer significant.

The main specifications of the CA 3189E are listed in table 1.

The block diagram of an IF circuit incorporating the CA 3189E is shown in figure 2. As can be seen, the basic design conforms to the now almost universally adopted approach of a single IF filter *before* the amplifier and demodulator stages. This is in contrast to the older method of interposing several filters between successive amplifiers.

1

HF — front end — IF — IF amplifier/limiter/demodulator — MPX — stereo decoder — L / R — LF

AGC

AFC

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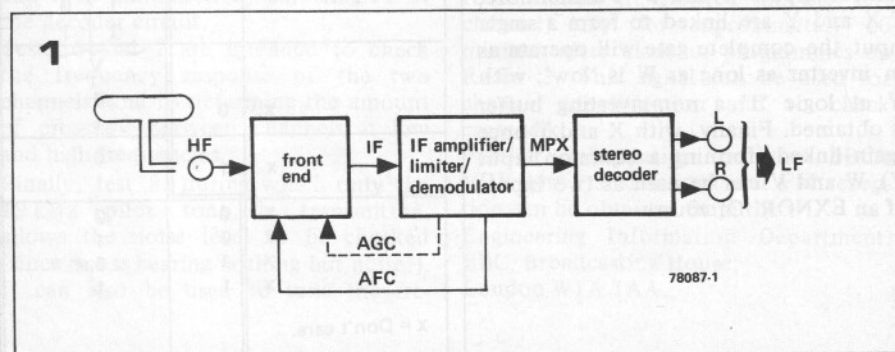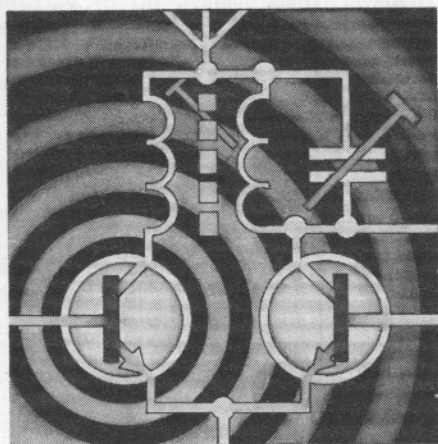
Inside the CA 3189E

The operation of the CA 3189E can best be explained with reference to the internal block diagram of the device, which is shown in figure 3.

The input IF signal is fed to three limiting amplifiers connected in cascade. The gain of these stages is such that limiting occurs at an input voltage of 12 μV. If one takes into account the gain of the front-end, then this is equivalent to an antenna sensitivity of 1 to 2 μV or even less.

The output of each of the amplifier/limiters is also fed to a peak level detector, the outputs of which are in turn summed to provide the drive voltage for the signal strength meter and the control voltage for the AGC circuit. The latter provides an output signal which goes high (i.e. approx. 9.5 V) when the input signal to the IC falls below a certain threshold value which is set by P1.

Once amplified and limited, the IF signal is fed to the demodulator, which employs a quadrature-tuned circuit connected between pins 8, 9 and 10 of the IC. In addition to the MPX audio signal, the demodulator provides a control signal for the AFC circuit. As already mentioned, the audio mute (squelch) is triggered both by inadequate audio signal level (this is determined by the level detector connected to the demodulator) and by frequency deviation. The AFC circuit provides a DC control voltage which varies according to the extent to which the tuner deviates from the station frequency. This is fed to the 'deviation mute' circuit, which in turn (via the mute drive and external mute circuits) controls the squelch signal. The level at which the noise muting cuts in can be varied by means of the external mute circuit.

The voltage level at pin 12 of the IC can also be used as an on-channel indicator. When an FM transmission is being received the voltage at this pin is 0 V, whilst if the receiver is not tuned to a station it will be roughly 5.6 V.

A complete amplifier/limiter/demodulator

The circuit diagram of a complete IF amplifier/limiter/demodulator incorporating the CA 3189E is shown in figure 4.

T1 and associated components form the input buffer amplifier of figure 2. There are various possibilities for the 10.7 MHz filter, and in principle either ceramic filters or LC tuned circuits can be employed. Generally speaking, however, ceramic filters are preferable since they do not require alignment. Several possible types are listed in table 2, along with the values of the corresponding resistors and capacitors in each case. If two filters connected in series are used, they must of course have the same resonant frequency (which in the case of the SFE 10.7 MA means that they should both have the red colour code).

The bandwidth-limited IF signal is then fed to the input of the IC. The quadrature tuned circuit is formed by a double-tuned LC network. It is also possible to use a single tuned circuit, in which case L3 is omitted and a through connection made along the dotted line. R9 is also omitted and the value of R7 altered to 2k7. In the event of a single tuned circuit being employed, an IF transformer, type 33733 (Toko), can be used instead of L2. The advantage of a single tuned circuit is that alignment becomes much simpler, however it also inevitably

Figure 1. Block diagram of a typical FM tuner.

Figure 2. The design of the IF circuit conforms to the now commonly adopted approach of a single 10.7 MHz filter before the amplifier/limiter stage.

Figure 3. Internal block diagram of the CA 3189E. The actual circuit diagram of the IC is rather difficult to follow, comprising as it does some 100 transistors, almost 100 resistors, a dozen diodes and 15 capacitors!

Table 1. Main characteristics of the CA 3189E

$(U_b = 12\ V;\ T_{amb} = 25°C)$

DC conditions

(no input signal)	min.	typ.	max.	
supply current	20	31	44	mA
DC voltages pin 1	1.2	1.9	2.4	V
pin 2	1.2	1.9	2.4	V
pin 3	1.2	1.9	2.4	V
pin 15 (AGC)	7.5	9.5	11	V
pin 10 (U_{ref})	5	5.6	6	V

AC conditions

input sensitivity (limiting threshold)	—	12	25	μV
AM rejection	45	55	—	dB
output voltage (pin 6)	325	500	650	mV
harmonic distortion				
single tuned circuit	—	0.5	1	%
double tuned circuit	—	0.1	—	%
signal-to-noise ratio	65	72	—	dB

Table 2. Some possible IF filters

type	bandwidth (kHz)	R4,R5,C3,C4
SFJ 10.7 MA (red)*	280	
SFW 10.7 MA (red)*	220	R4 = 330 Ω R5 = 330 Ω C3 and C4 are replaced by wire links
two filters SFE 10.7 MA (red)*	280	
two filters** CFS 10.7 A	300	
BBR 3132 A**	240	R4 = 1 k R5 = 560 Ω C3 = 100 n C4 = 100 n

* Murata
** Toko

entails an increase in harmonic distortion from around 0.1% to 0.5%.

The MPX audio signal is fed out via pin 6 of the IC. R11 and C11 form the de-emphasis network. If the circuit is followed by a stereo decoder, C11 should have a value of 56 p. If, on the other hand, one is only interested in mono reception C11 is increased to 6n8 and the MPX signal represents the audio output signal.

The AFC voltage U_{afc}, is brought out to pin 7. The relationship between U_{afc} and the average value of input frequency, f_i, is illustrated by the graph in figure 5a. Since, strictly speaking, the CA 3189E provides an AFC current instead of a voltage, the relationship shown in figure 5a is only valid if the AFC output is not loaded too heavily. At the IF frequency of 10.7 MHz the AFC voltage will be 5.6 V, and equal to

the AFC reference voltage provided by the IC. Any slight differences can be eliminated by adjusting preset P2. The relationship between the AFC current, I_{afc}, (flowing into the IC) and the input frequency, f_i, is illustrated in figure 5b. The response shown is virtually independent of load conditions. In addition to providing the feedback signal to the front-end, the AFC output can be used to drive a centre zero tuning meter, which is connected in series with R8. The mute drive signal is fed out to pin 12, and the external mute circuit which, with the aid of P3, allows the muting threshold to be varied, is connected between pins 12 and 5. The deviation mute threshold is determined by the value of R8. With the value shown muting occurs when the average input frequency deviates by more than roughly 35 kHz from the required 10.7 MHz.

The signal strength meter is connected to pin 13 of the IC. The meter response is approximately logarithmic (i.e. the voltage at pin 13 increases as the logarithm of the input voltage), thereby permitting input signals of widely differing strength to be displayed. Thus, for example, an input voltage of 10 μV will cause a current of approximately 1 μA to flow through the meter, whilst an input voltage of 100 mV will produce a meter current of roughly 100 μA.

The components shown in dotted lines are part of the AGC circuit. As was mentioned earlier, such a facility is not always desirable. The voltage at pin 16 controls the AGC threshold, i.e. the signal level at which gain reduction occurs. This can therefore be varied by means of preset P1. If AGC is not desired, the components in question are simply omitted and pin 16 connected to ground.

Construction

The circuit can be mounted on the printed circuit board of figure 6. To improve stability the board is extensively clad with copper earth planes.

The board is designed to accommodate several types of IF filter. The SFW 10.7 MA is mounted on the smaller rectangular contour, whilst the SFJ 10.7 MA is shown as the dotted oval. The CFS 10.7 A and SFE 10.7 MA, two of which must be connected in series, have three terminals and are shown as small ovals. Although the input and output connections of ceramic filters are sometimes marked on the case (a red dot marks the output), they are constructed symmetrically, so that in principle it is possible to mount them two ways. If ceramic filters are used, then capacitors C3 and C4 should be replaced by wire links.

By far and away the best results are obtained if linear phase filters, type 3132A from Toko, are used. This filter contains six coupled tuned LC circuits which are pre-aligned at the

4
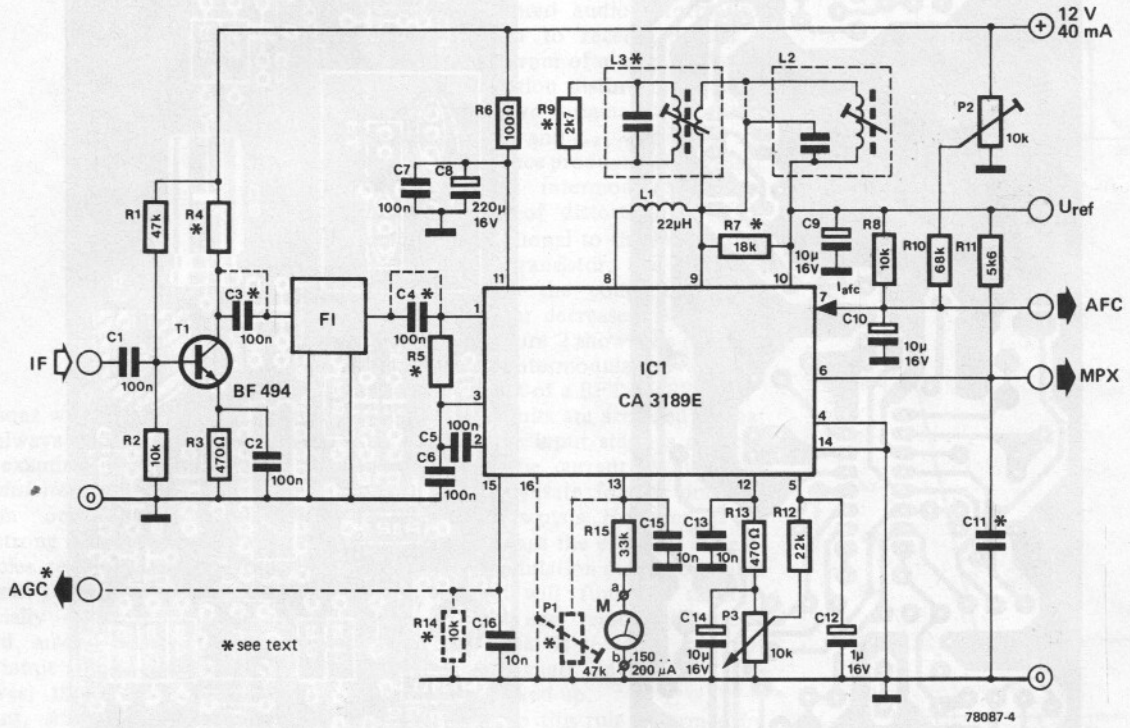
5a
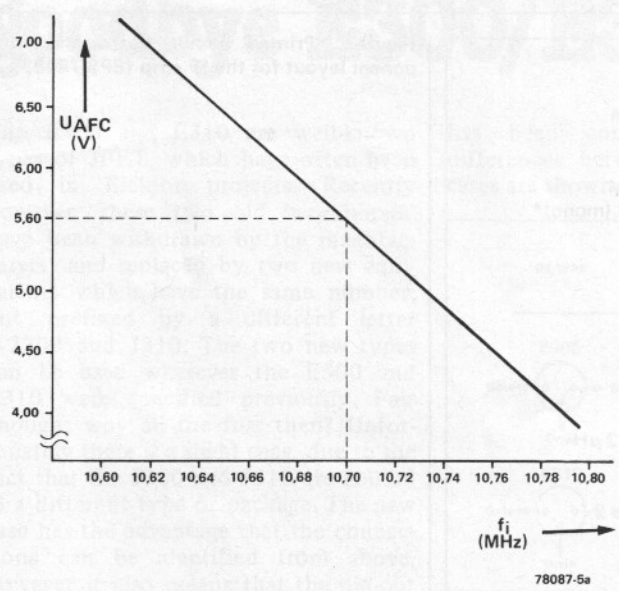
5b
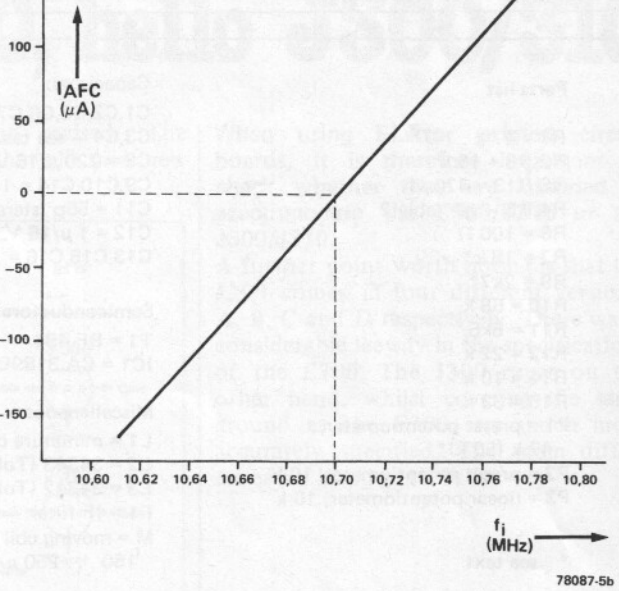
Figure 4. Complete circuit diagram of the IF amplifier/limiter/demodulator. Most types of IF filter can be used for F1; several possibilities are listed in table 2. If AGC is not required, P1 and R14 are omitted.

Figure 5. AFC voltage (a) and AFC current (b) as a function of input frequency. The response of figure (a) is strongly influenced by load conditions, whilst the second is independent of load.

factory, and has a group delay of less than 0.5 μs over the frequency range 10.525 to 10.875 MHz. The linear phase filter is mounted in the large rectangle shown on the p.c.b. The input and output connections are indicated on the underside of the filter, whilst the input is also marked on the case of the filter by a dot. As is apparent from table 2, capacitors C3 and C4 are required if the linear phase filter is used.

Finally, it is recommended that the circuit be screened, using for example copper clad board or tin plate.

Alignment

The alignment procedure is comparatively simple. With the AFC disconnected, one tunes to an FM transmission, whereupon L2 is adjusted for maximum output signal. If L3 is used, the next step is

6
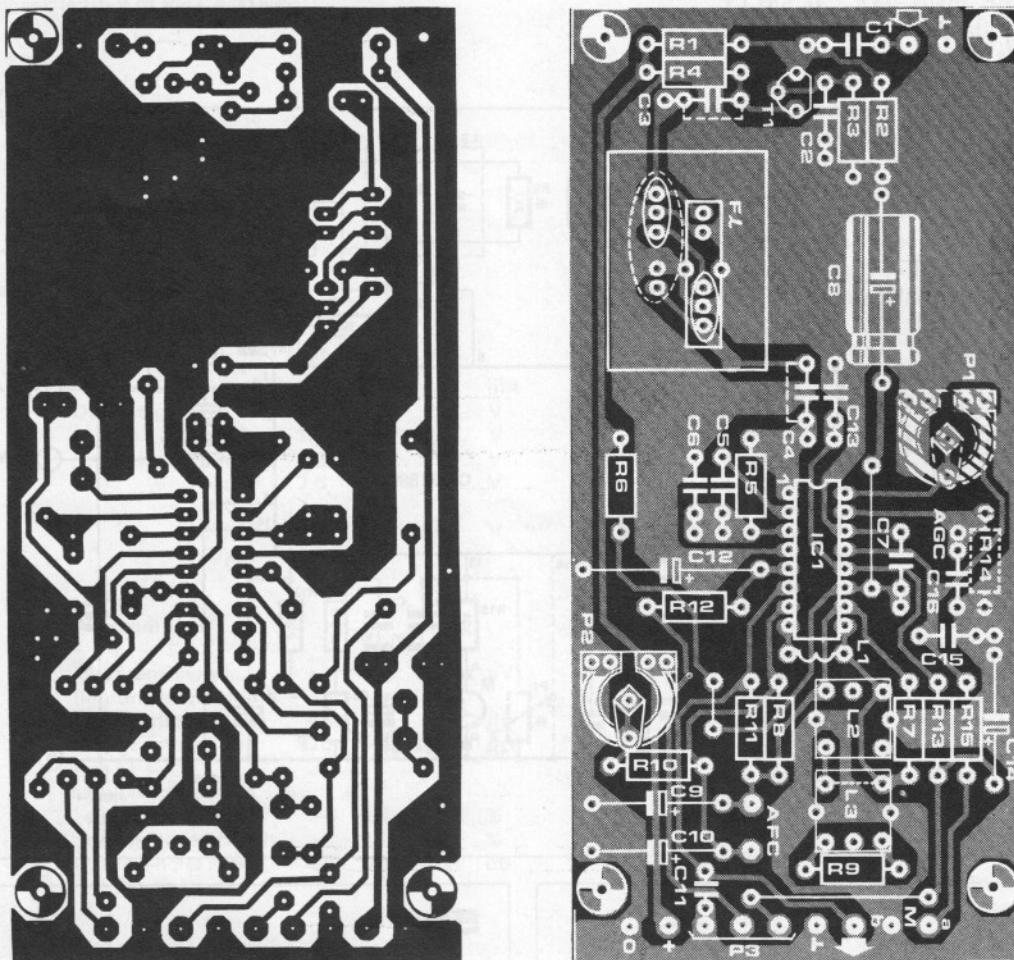
Parts list

R1 = 47 k
R2,R8 = 10 k
R3,R13 = 470 Ω
R4,R5 — see table 2
R6 = 100 Ω
R7 = 18 k*
R9 = 2k7*
R10 = 68 k
R11 = 5k6
R12 = 22 k
R14 = 10 k*
R15 = 33 k
P1 = preset potentiometer,
   47 k (50 k)*
P2 = preset potentiometer, 10 k
P3 = linear potentiometer, 10 k

* see text

Capacitors:
C1,C2,C5,C6,C7 = 100 n
C3,C4 — see table 2
C8 = 220 μ/16 V
C9,C10,C14 = 10 μ/16 V
C11 = 56p (stereo), 6n8 (mono)*
C12 = 1 μ/16 V
C13,C15,C16 = 10 n

Semiconductors:
T1 = BF 494
IC1 = CA 3189E (RCA)

Miscellaneous:
L1 = miniature choke, 22 μH
L2 = 34343 (Toko)*
L3 = 34342 (Toko)*
F1 = IF filter — see table 2
M = moving coil meter,
   150 . . . 250 μA

to adjust L3 for minimum output voltage; distortion should then be minimal. It goes without saying that the alignment procedure is greatly facilitated if one has suitable test gear — oscilloscope, high impedance millivoltmeter, distortion meter, FM test generator (note that a circuit for an FM test generator was published in Elektor 45). In the absence of a suitable millivoltmeter, one way of monitoring the output voltage of the circuit is to use the VU meter on a tape recorder. However it is also possible to obtain quite satisfactory results tuning by ear. The use of the BBC VHF stereo test transmissions as an aid to alignment of the IF strip is discussed in a separate section with the article on the stereo decoder published in this issue.

The AFC control voltage is adjusted by means of P2. With the AFC inoperative one tunes to a fairly weak transmission and then switches in the AFC. In most cases the strength of the reception will change (this will be apparent audibly or as a different reading on the signal strength meter). The adjustment procedure basically consists of restoring the original reception. Once P2 has been correctly set, switching the AFC in and out should have no effect upon the strength of a received signal.

The AGC threshold voltage is set by means of P1, and will depend upon the gain of the front-end which is used. The input level at which AGC occurs can be varied between roughly 200 μV and 200 mV.

Intermodulation distortion

The reasons why automatic gain control is not always desirable become clearer if we examine the phenomenon of *intermodulation distortion*. This type of distortion occurs particularly when several strong transmissions on adjacent frequencies reach the tuner front-end. As a result of various non-linearities in — especially — the input stage of the front-end, second, third, etc harmonics of the input signals are generated. In themselves, these are not necessarily significant, since their frequencies are considerably removed from the original input signals. However in addition to the simple harmonics, all sorts of sum and difference products are produced.

These intermodulation products are often at frequencies close to that of the input signals, and can considerably distort the desired audio information which we wish to receive. Figure 1 shows the spectrum of a signal afflicted by intermodulation distortion. In addition to the two original transmitter frequencies f_1 and f_2, a number of sum and difference products are present. The degree of intermodulation, and thus the level of distortion, is often directly proportional to the DC current of the input transistor, and increases considerably as the collector current of the transistor decreases. By way of an example, figure 2 shows the relationship between intermodulation and the collector current of a BFT 66/BFT 67. Many AGC circuits are arranged so that the gain of the input stage is reduced (and with it the current through the stage) to compensate for the presence of large input signals. However, as we have seen, this has the effect of increasing the intermodulation distortion. Such AGC circuits will function satisfactorily if only one reasonably strong transmitter signal is received, but not if two such signals on adjacent frequencies are picked up.

An exception to this rule is formed by AGC circuits which employ PIN-diode attenuators, since the current through the input transistor then remains unaffected.
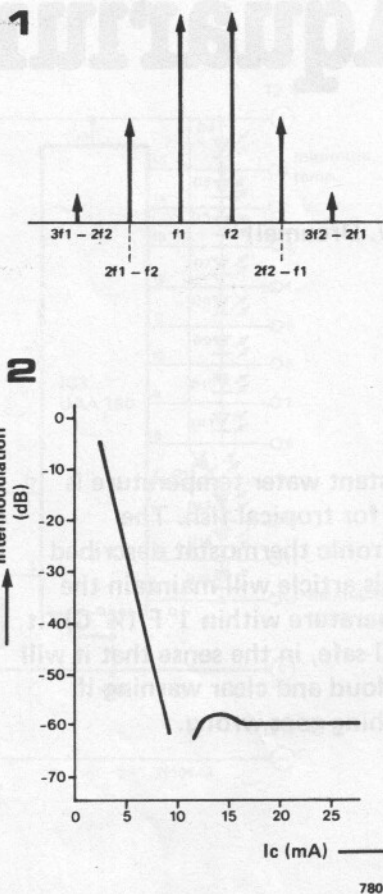
goodbye E300/E310, hello J300/310

The E300 and E310 are well-known types of JFET, which have often been used in Elektor projects. Recently however, these two old 'workhorses' have been withdrawn by the manufacturers, and replaced by two new equivalents which have the same number, but prefixed by a different letter — J300 and J310. The two new types can be used wherever the E300 and E310 were specified previously. Fair enough, why all the fuss then? Unfortunately there is a slight snag, due to the fact that the J300 and J310 are housed in a different type of package. The new case has the advantage that the connections can be identified from above, however it also means that the pin-out

has been completely revised. The differences between the old and new cases are shown below:

as was	as is
E300	J 300
E310	J 310
bottom view	
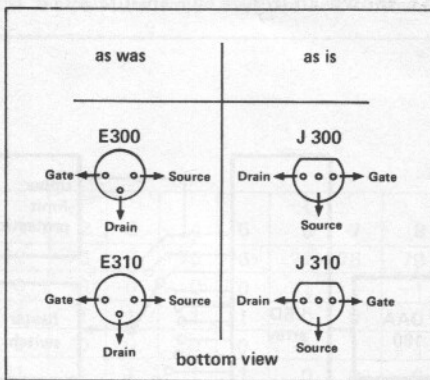
When using Elektor printed circuit boards, it is therefore important to check whether they are intended to accommodate the E300/E310 or the J300/J310.

A further point worth noting is that the J300 comes in four different versions, A, B, C and D respectively. There was a considerable leeway in the specifications of the E300. The J300 types on the other hand, whilst covering the same ground as the E300, are much more accurately specified. The main differences are listed in table 1.

Table 1.

Characteristics		J300A		J300B		J300C		J300D		Unit	Test Conditions
		Min	Max	Min	Max	Min	Max	Min	Max		
I_{DSS} (Note 2)	Saturation Drain Current	4	9	7	15	12	25	21	45	mA	$V_{DS} = 10$ V $V_{GS} = 0$
$V_{GS(off)}$	Gate Source Cutoff Voltage	−1.5	−3.0	−2.0	−4.0	−2.5	−5.0	−3.5	−7.0	V	$V_{DS} = 10$ V $I_D = 1$ nA

Aquarium thermostat

(W. v. Dreumel)

Constant water temperature is vital for tropical fish. The electronic thermostat described in this article will maintain the temperature within 1°F (½°C). It is fail-safe, in the sense that it will give loud and clear warning if anything goes wrong.

When keeping tropical fish in an aquarium, a good heating system is required. It should meet the following specifications:

- It must be possible to set the desired temperature accurately.
- The circuit must maintain the temperature within ± 1°F (± ½°C).
- The actual temperature must be clearly displayed.
- A clear, audible warning must be given if the temperature falls too low or rises too high; furthermore if the temperature rises above the preset limit the heating must certainly be switched off.

A block diagram of the complete system is given in figure 1. A temperature sensor provides an output voltage that varies linearly with temperature. An offset compensation is used to set the desired measuring range; the resulting voltage is amplified and used to control a LED display, providing a clear replacement for the old mercury thermometer. The control voltage for the heater switch is taken from the desired 'tap' on the LED display.

As shown in figure 2, an LM 3911 is used as a temperature sensor. This IC gives an output voltage that rises with temperature at the rate of 10 mV/°K. At 295°K (72° Fahrenheit, or 22°C) the output voltage is 2.95 V. If this temperature is taken as the low end of the scale, an offset of 2.95 V is required. This is achieved with the voltage divider chain R2 ... R5 and P1; with P1 correctly set, the voltage at the R3/R4 junction rises from 0 V (at 72°F) at the rate of 10 mV/°K. With the gain of IC2 set at x100, this results in an output voltage that rises at 1 V/°C. Alternatively, if a scale calibrated in degrees Fahrenheit is required, a gain of x90 can be obtained by replacing R8 by two 18 k resistors connected in parallel (giving an equivalent resistance of 9 k). In this case, the output voltage will increase at 0.5 V/°F.

For the UAA 180, 'full scale' corresponds to an input voltage of 6 V. Each of the twelve LEDs D4 ... D15 therefore corresponds to a temperature step of 1°F (or 0.5°C, for R8 = 10 k); the total measuring range is 12°F or 6°C. The 'low end' of the range can be set by P1. If four green LEDs are used

1

2

* Fahrenheit scale : R8 = 9K (18K//18K)
Centigrade scale : R8 = 10K
(see text)

top view 3911

top view 3911

pin 4 connected to case

79105 - 2

in the middle of the range and yellow and/or red LEDs towards the end, a clear indication of temperature is obtained.

A multi-position switch is used to select the cathode of the LED that corresponds

Figure 1. This simplified block diagram illustrates the basic principle of the aquarium thermostat.

Figure 2. This section of the circuit works as a thermometer with high accuracy over a limited range of temperatures.

Table 1.

switch position		1	2	3	4	5	6	7	8	9	10	11	12
temp. (°F)	<72	72	73	74	75	76	77	78	79	80	81	82	83
T1	0	0	0	0	0	0	1	1	1	1	1	1	1
T2	1	1	1	1	1	1	0	0	0	0	0	0	0
T3	0	0	0	0	0	0	1	1	1	1	1	1	1
triac	1	1	1	1	1	1	0	0	0	0	0	0	0
heater	1	1	1	1	1	1	0	0	0	0	0	0	0
T4	0	1	1	1	1	1	1	1	1	1	1	1	0
T5	1	0	0	0	0	0	0	0	0	0	0	0	1
buzzer	1	0	0	0	0	0	0	0	0	0	0	0	1
T6	0	0	0	0	0	0	0	0	0	0	0	0	1
T7	1	1	1	1	1	1	1	1	1	1	1	1	0
relay	1	1	1	1	1	1	1	1	1	1	1	1	0

Figure 3. The second part of the circuit is the heater switch with additional fail-safe circuits.

Figure 4. This diagram illustrates the way in which the two parts of the circuit are interconnected. A multi-position switch is used to select the desired operating point for the heater switch.

Figure 5. A suitable power supply circuit for the aquarium thermostat.

to the desired temperature. The voltage at this point is used to control the heater switch shown in figure 3. As long as the water temperature is lower than the selected value, the voltage at the base of T1 will be high (see figure 4) so that this transistor is cut off. T2 will turn on, lighting the LED in the opto-coupler (IC4). This, in turn, causes T3 to turn off; the voltage across D21 and D22 rises above their zener voltage so that gate current flows into the triac. The heater is turned on.

When the desired temperature is reached, the voltage at the base of T1 will drop so that this transistor is turned on. Via the steps outlined above, this causes the triac to extinguish — turning off the heater. As the water temperature swings up and down around the required value, the heater will be switched off and on — maintaining a fairly constant temperature.

If the heater fails, the temperature will drop until even the lowest LED in the scale goes out. At this point, T4 will turn off; T5 will then conduct so that the buzzer sounds.

On the other hand, if the heater remains on for some reason (if the triac fails, for instance) the temperature will rise towards the upper limit of the range. At that point, T6 will turn on. Via D24, T4 and T5 this operates the buzzer; simultaneously, T7 is turned off so that the relay drops out — disconnecting the supply to the heater.

Construction and calibration

For safety reasons, the heater must be extremely well insulated. This applies, of course, to any heater used in an aquarium . . . .

Although the block diagram shows the temperature sensor dangling in the water, this is by no means the best place. It is more practical to clamp or glue it to the outside of the glass. The best position (relative to the position of the heater) can be determined by watching the temperature fluctuation on the LED scale with the circuit in operation.

There is only one calibration point in the circuit: P1. This is used to set the desired measuring range — using a normal thermometer as a reference.

4

monoselektor

27½°C   4   12   R24/T6

9   7
25° C   10   6   S
24½°C   11   5
24° C   12   4
23½°C   13   3
23° C   14   2
22½°C   15   1
22° C   R20/T4

12 V

12 V

R12   T1
R11
R13
79105-4

UAA 180

12 V

5

Tr1   B40C1000   IC5 7812   12 V
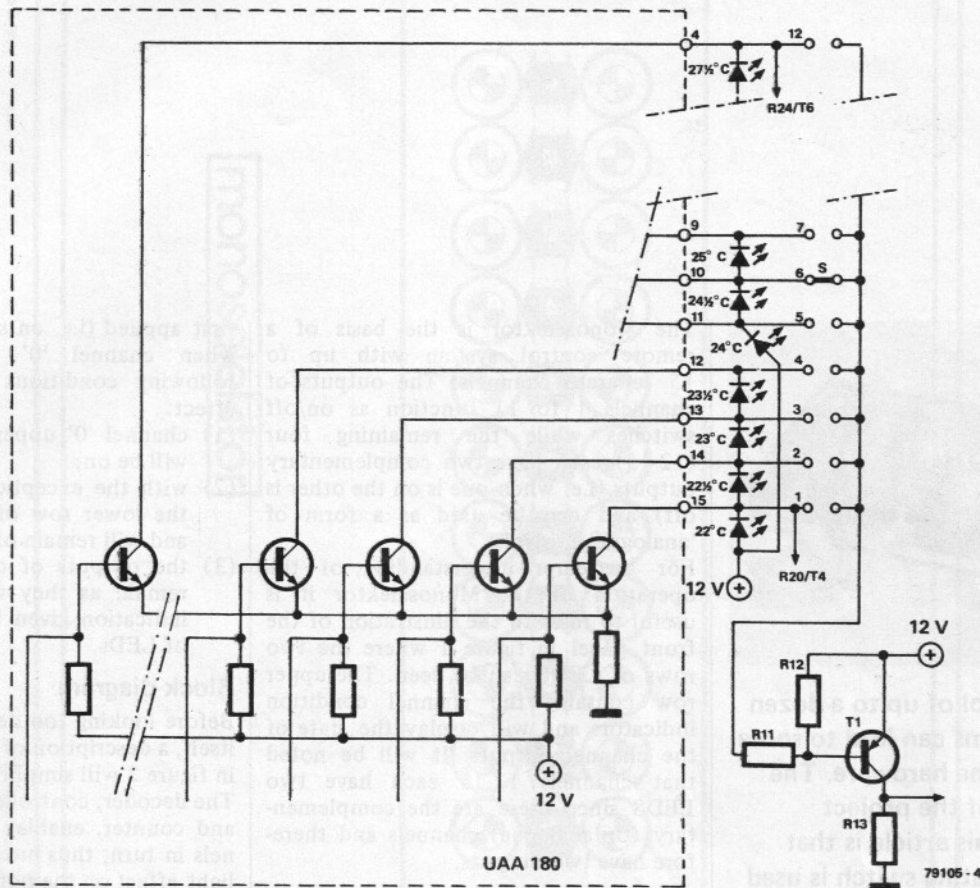
15 V/1 A
15 V/1 A   C4 470µ 25V   C5 330n   C6 10µ 25V
C7 100µ 25V   C8 330n   C9 10µ 25V   0
IC6 79L12   12 V
79105-5
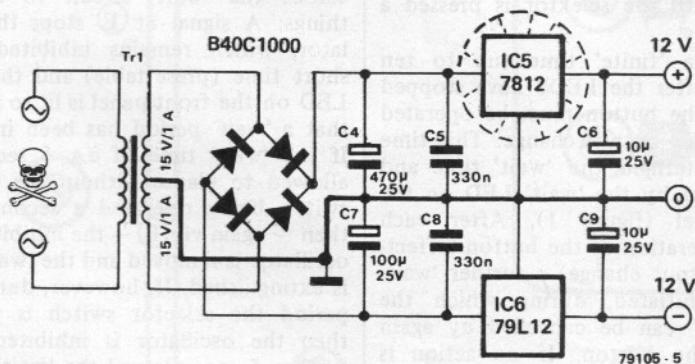
Initially, P1 should be set to minimum resistance (this corresponds to the lowest 'minimum temperature' setting). If even this 'minimum temperature' proves too high, due to component tolerances, R4 should be decreased to 22 k. On the other hand, if the 'minimum' setting remains too low even with P1 set to maximum, R4 can be increased to 33 k. It is not a good idea to increase the value of P1 — adjustment is critical enough as it is: the nominal adjustment range for the minimum temperature is from 57°F to 153°F! It might even be a good idea to use a multi-turn potentiometer . . .

monoselektor
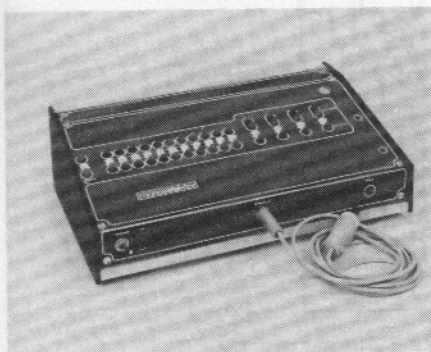
Remote control of up to a dozen separate systems can lead to some confusion in the hardware. The main feature of the project described in this article is that only one operating switch is used to control up to 15 outputs with either 'digital' or 'analogue' capabilities (together with a visual indication of the condition of each channel).

One other highly desirable (and unusual) feature has been included. The Monoselektor will allow you to check that you really are turning the (remote controlled) central heating up before inadvertently closing the (remote controlled) garage door during the wife's car parking operations.

The Monoselektor is the basis of a remote control system with up to 15 separate channels. The outputs of channels 1 to 11 function as on/off switches while the remaining four (12-15) each have two complementary outputs (i.e. when one is on the other is off) and can be used as a form of 'analogue' control.

For a clearer understanding of the operation of the Monoselektor it is useful to refer to the illustration of the front panel in figure 1 where the two rows of LEDS can be seen. The upper row contains the channel condition indicators and will display the state of the channel outputs. It will be noted that channels 12-15 each have two LEDS since these are the complementary (or analogue) channels and therefore have two outputs.

Channel operation

The LEDs forming the lower row are used as the means by which each channel is selected and do in fact 'run' (i.e. light in sequence from left to right). The 'flow chart' in figure 2 gives a clear indication of the methods of control for the different channels of the Mono-selektor. The selection of a channel is carried out by pressing the 'selektor' button when the LED in the lower row of the required channel is lit. This will stop the running LEDS at that point but the channel output state will not be altered until the selektor is pressed a second time.

There is a 'finite' time (up to ten seconds) after the LEDS have stopped in which the button must be operated to effect an output change. This time period is termed the 'wait' time and is indicated by the 'wait' LED on the front panel (figure 1). After each further operation of the button (effecting an output change) a further 'wait' time is initiated, during which the 'command' can be cancelled by again pressing the button. If no action is taken within the 'wait' time, the running LEDS resume.

The 'stand-by' channel

The 'stand-by' mode is exactly what the term implies. The Monoselektor will be on stand-by when (a) mains power is

first applied (i.e. on switch on) and (b) when channel '0' is selected. The following conditions will then be in effect:
(1) channel '0' upper and lower LEDs will be on;
(2) with the exception of channel '0', the lower row of LEDs will be off and will remain off;
(3) the outputs of channels 1-15 will remain as they were with a visual indication given by the upper row of LEDs.

Block diagram

Before looking too deeply at the circuit itself, a description of the block diagram in figure 3 will simplify matters.

The decoder, controlled by the oscillator and counter, enables each of the channels in turn, thus producing the running light effect on the bottom row of LEDs. The 'on' time of each LED can be varied by altering the frequency of the oscillator.

The section of the circuit labelled 'automatic reset' ensures that, when the circuit is initially switched on, channel 0 is activated and channels 1 . . . 11 are disabled, i.e. the Monoselektor is in the standby mode. When the selector switch is depressed, the pulse shaper (which serves to eliminate the effects of contact bounce) supplies a trigger pulse, Ⓒ, to the 'wait' circuit. This initial operation of the selector switch causes the 'wait' circuit to do two things: A signal at Ⓔ stops the oscillator, which remains inhibited for a short time (presettable) and the 'wait' LED on the front panel is lit to indicate that a 'wait' period has been initiated. If the 'wait' time of e.g. 5 seconds is allowed to elapse without the selector switch being operated a second time, then — again via Ⓔ — the inhibit on the oscillator is removed and the 'wait' LED is extinguished. If, however, during this period the selector switch is pressed, then the oscillator is inhibited for a further 5 seconds and the 'wait' circuit provides a pulse output at Ⓓ. This activates the output of the channel at which the running light was stopped (if that channel was already activated the pulse will have the opposite effect, i.e. disable the output in question).

1
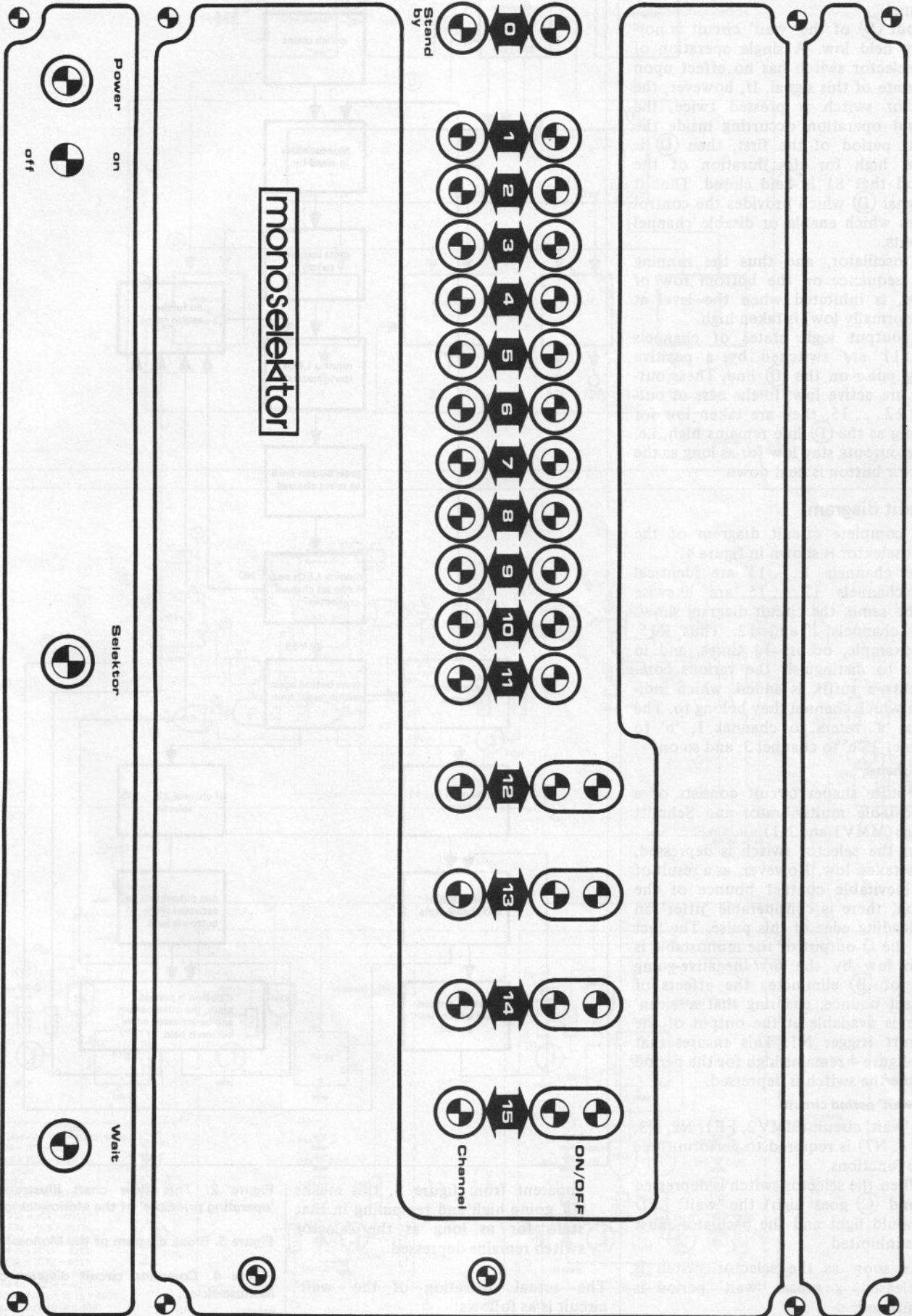
Power
off
on

monoselektor

Stand by

0 1 2 3 4 5 6 7 8 9 10 11

12 13 14 15

Channel

ON/OFF

Selektor

Wait

The oscillator can also be inhibited by means of a signal at (H), which is in fact the output of channel 0 (the standby channel).

Output (D) of the 'wait' circuit is normally held low. A single operation of the selector switch has no effect upon the state of this signal. If, however, the selector switch is pressed twice, the second operation occurring inside the 'wait' period of the first, then (D) is taken high for the duration of the period that S1 is held closed. Thus it is signal (D) which provides the control pulses which enable or disable channel outputs.

The oscillator, and thus the running light sequence on the bottom row of LEDs, is inhibited when the level at (E) (normally low) is taken high.

The output logic states of channels 1 . . . 11 are switched by a positive going pulse on the (D) line. These outputs are active low. In the case of outputs 12 . . . 15, they are taken low for as long as the (D) line remains high, i.e. these outputs stay low for as long as the selector button is held down.

Circuit diagram

The complete circuit diagram of the Monoselektor is shown in figure 4.

Since channels 1 . . . 11 are identical and channels 12 . . . 15 are likewise all the same, the circuit diagram shows only channels 1 and 12. Thus R15, for example, occurs 11 times, and in order to distinguish the various components a suffix is added, which indicates which channel they belong to. The suffix 'a' refers to channel 1, 'b' to channel 2, 'c' to channel 3, and so on.

Pulse shaper

The pulse shaper circuit consists of a monostable multivibrator and Schmitt trigger (MMV1 and N1).

When the selector switch is depressed, (B) is taken low. However, as a result of the inevitable contact bounce of the switch, there is considerable 'jitter' on the leading edge of this pulse. The fact that the $\overline{Q}$ output of the monostable is taken low by the *first* negative-going edge of (B) eliminates the effects of contact bounce, ensuring that a 'clean' pulse is available at the output of the Schmitt trigger N1. This ensures that (C) in figure 4 remains high for the period of time the switch is depressed.

The 'wait' period circuit

The 'wait' circuit (MMV2, FF1, N2, N3, N5 . . . N7) is required to perform three basic functions.

1) When the selector switch is depressed (and (C) goes high) the 'wait' LED should light and the oscillator must be inhibited.

2) As soon as the selector switch is released, a preset 'wait' period is initiated.

3) If, within the 'wait' period, the selector switch is pressed *again*, a control pulse must be supplied to the appropriate channel. As was
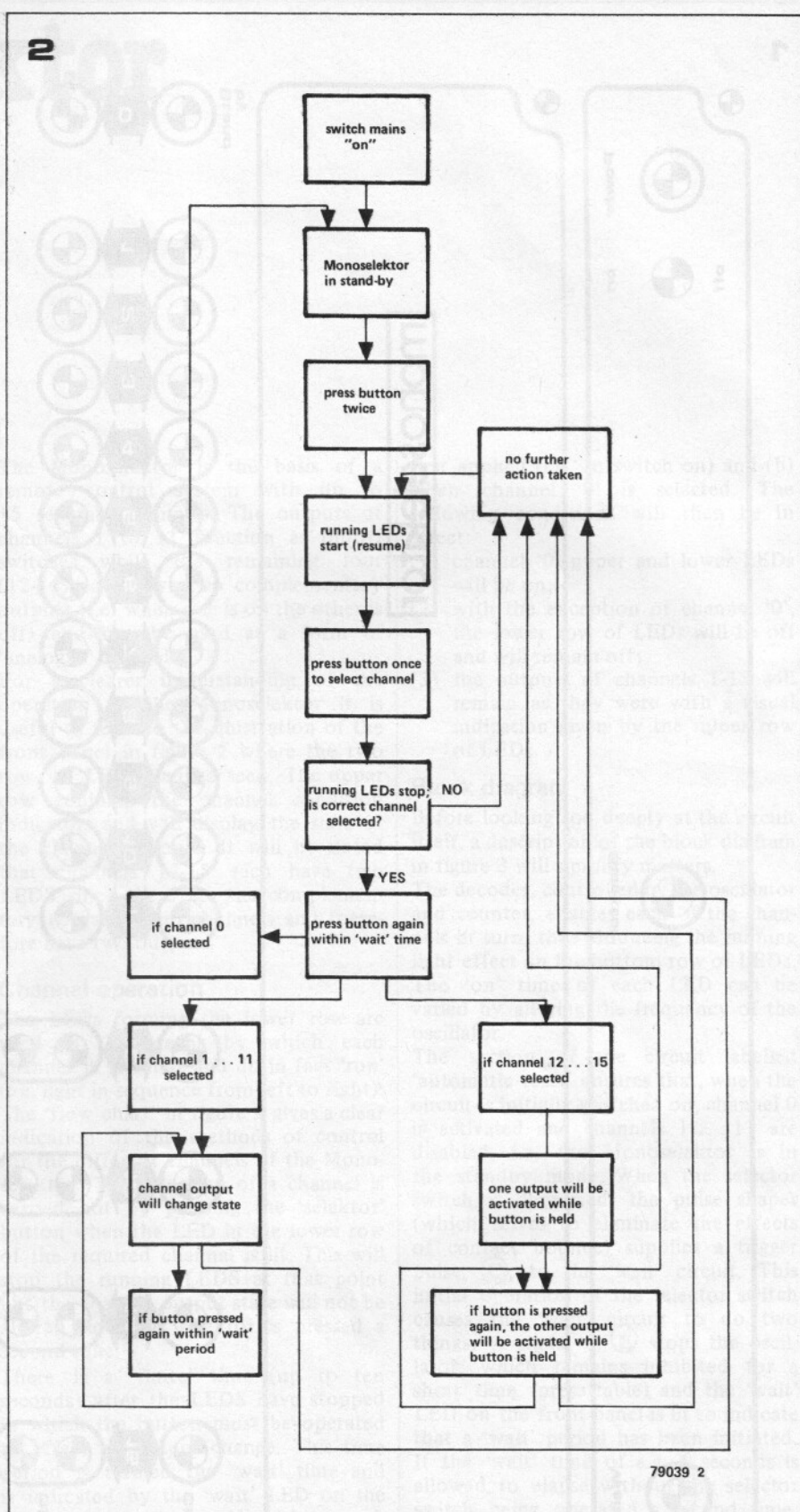
apparent from figure 3, this means (D) going high and remaining in that state for as long as the selector switch remains depressed.

The actual operation of the 'wait' circuit is as follows:

When the selector switch is pressed for the first time, (C) goes high, taking the output of N7 ((F)) low. This in turn causes the output of N3 ((E)) to go high,

Figure 2. This flow chart illustrates the 'operating principle' of the Monoselektor.

Figure 3. Block diagram of the Monoselektor.

Figure 4. Complete circuit diagram of the Monoselektor.

3

pulse shaper → 'wait' time → oscillator + counter   Q0 ... Q3   automatic reset

decoder   A0 ... A3

Q0   Q1   Q2 ... Q11   Q12   Q13 ... Q15

channel 0 (stand-by) | channel 1 | channels 2 ... 11 | channel 12 | channels 13 ... 15

1   2 ... 11   12L   12R   13L ... 15L   13R ... 15R

79039

4

MMV 1   MMV 2   N7   N3   N8   N4   IC4 4520
R2 6kB   R3 4k7   P1 50k   R4 22k   R7 4k7   P2 50k
C2 22µ 16V   C3 470µ 16V   C4 10µ 16V   C5 100µ 16V
R1 10k   C1 1µ 16V   Selektor S1   N1   N2   N5   N6   FF1
R5 120Ω   R6 3k3   D1 Wait   T1 TUN
Q3 Q2 Q1 Q0   14 13 12 11   CI 9   R 15
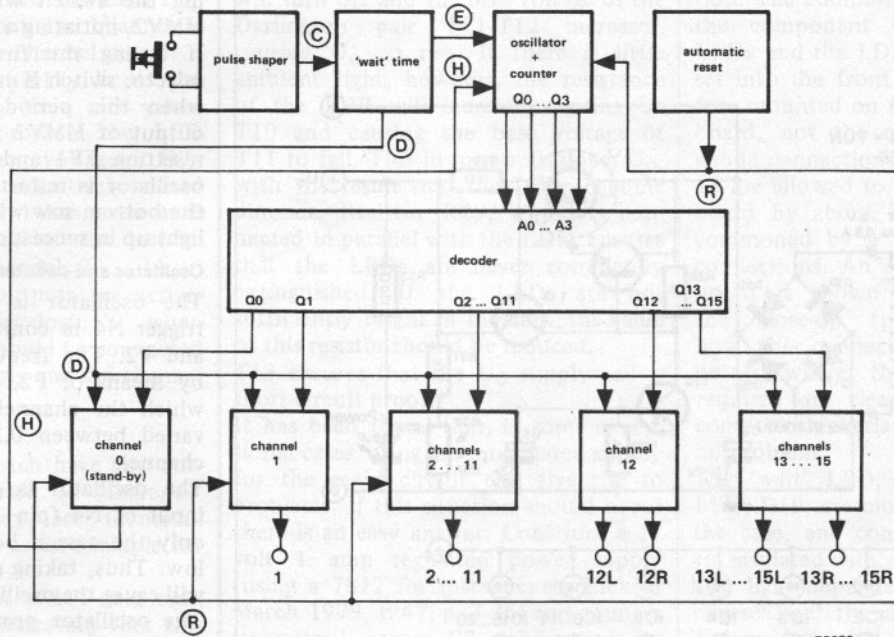R8 3k3   R9 100k   C9 10n   T2 TUN   R10 100k   C6 100µ 16V

A3 A2 A1 A0   22 21 3 2

IC5 4514   STROBE   INHIBIT   Q0   Q1   Q2,Q3,Q4,Q5,Q6,Q7,Q8,Q9,Q10,Q11   Q12   Q13,Q14,Q15
10 . 8 . 7 . 6 . 5 . 4 . 18.17. 20 . 19   14   13 . 16 . 15

channel 1 (a)   N9   N10a   D2   D4a   FF2   FF3a
R11 120Ω   R12 3k3   R15 120Ω   R16 3k3   T3 TUN   T5a TUN
D5a   D6a DUS   R18a 120Ω   R19a 3k3   R17 150Ω   D7a   T6a TUN   1N4001

channel 12 (1)   N11l   D8l   FF4l
R20 120Ω   R21 3k3   T7l TUN
D9l green   D10l   N12l   N13l   D12l red   D13l DUS
R23 120Ω   R24 3k3   R25 3k3   R26 120Ω
R22 150Ω   D11l   T8l   2x TUN   T9l   D14l   R27 150Ω   1N4001

channels 2 ... 11
2 - b   7 - g
3 - c   8 - h
4 - d   9 - i
5 - e   10 - j
6 - f   11 - k

channels 13 ... 15
13 - m
14 - n
15 - o

U0 Stand by   D3   R13 120Ω   R14 3k3   T4 TUN

MMV1,MMV2 = IC1 = 4528,4098
N1 ... N4 = IC2 = 4093
N5 ... N8 = IC3 = 4001
IC4 = ½ 4520
IC5 = 4514
FF1 = ½ IC6 = ½ 4013
FF2,FF3a = IC7 = 4013
FF3b,FF3c = IC8 = 4013
FF3d,FF3e = IC9 = 4013
FF3f,FF3g = IC10 = 4013
FF3h,FF3i = IC11 = 4013
FF3j,FF3k = IC12 = 4013
FF4l,FF4m = IC13 = 4013
FF4n,FF4o = IC14 = 4013
N9,N10a ... N10c = IC15 = 4081
N10d ... N10g = IC16 = 4081
N10h ... N10k = IC17 = 4081
N11l,N12l,N13l,N11m = IC18 = 4081
N12m,N12n,N13m,N13n = IC19 = 4081
N11n,N11o,N12o,N13o = IC20 = 4081

channel outputs
1 (a)   2 (b)   11 (k)   12L (lL)   12R (lR)   13L (mL)   13R (mR)   15L (oL)   15R (oR)

79039 4

5

T10, T11, T13 = TUN
T12 = 2N3055

6 ... 9 V
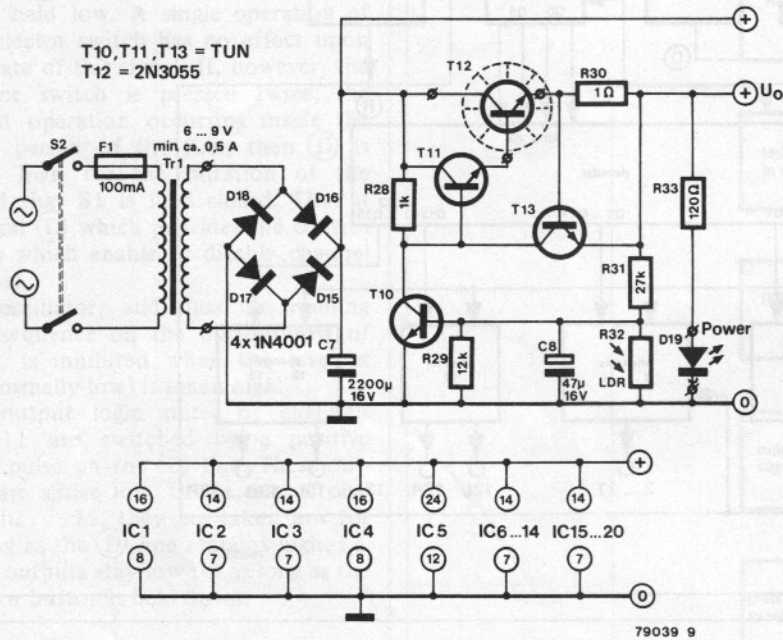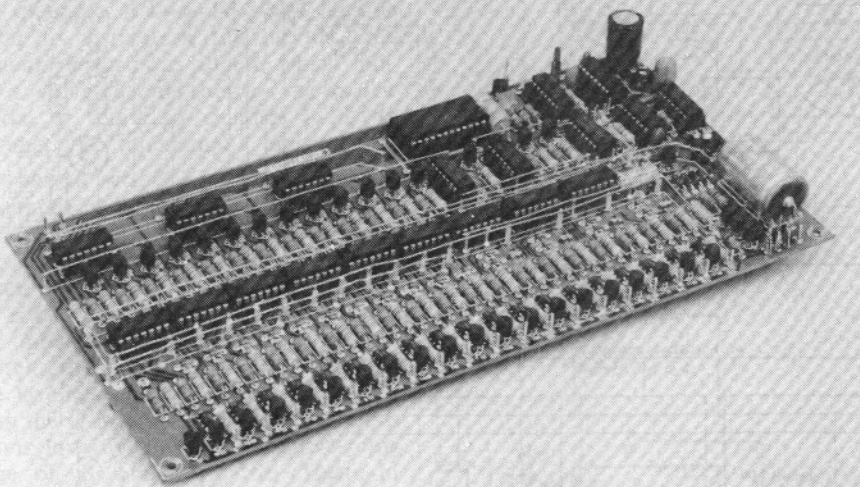min ca. 0,5 A

79039 9

a

thereby lighting LED D1, and inhibiting the oscillator. As long as Ⓕ remains low, the reset input of FF1 is also held low, allowing the flip-flop to be triggered. The RC-network comprising R4 and C4, which provides a delay of approx 250 ms, is included in order to suppress propagation delay 'spikes'.

When the selector switch is released, Ⓒ goes low, triggering MMV2 (via the Ⓑ input) and taking the Q output high. The output of N7 therefore remains low. The time for which the Q output remains high (i.e. the 'wait' time) is determined by the RC-constant of the monostable and can be varied by means of P1 between 1 and 10 seconds. As a result of Ⓒ going low, the clock input of FF1 is taken high (via N6) with the result that the Q̄ output of this flip-flop goes low, enabling gate N5.

If the selector switch is now pressed within the 'wait' time, Ⓒ will go high, taking the outputs of N2 low and N5 Ⓓ high. When the selector switch is released FF1 will not change state immediately, since the Q output of the flip-flop, which is high, will hold the

clock input of FF1 low via N6. Releasing the switch will however retrigger MMV2, initiating a new 'wait' period.

If during the first 'wait' period the selector switch is *not* pressed again, then when this period has elapsed the Q output of MMV2 will be returned low, resetting FF1 and taking Ⓔ low. The oscillator is restarted and the LEDs on the bottom row will once more begin to light up in succession.

Oscillator and counter circuit

The oscillator is formed by Schmitt trigger N4 in conjunction with C5, R7 and P2. The frequency can be altered by means of P2, allowing the rate at which the channels are scanned to be varied between 0.3 and 3 seconds per channel.

The oscillator is only enabled if the input of N4 (pin 12) is high, which is only the case if both inputs of N8 are low. Thus, taking either Ⓔ or Ⓗ high will cause the oscillator to be inhibited.

The oscillator provides the clock to a 4-bit binary counter, IC4. The binary output of the counter is decoded by IC5, a 4-16 line converter. The result is that the 16 outputs of IC5 ($Q_0 \ldots Q_{15}$) are taken high in succession.

Channel 0 — the stand-by channel

The principal components of this channel are FF2, T3 and T4. When the Q_0 output of IC5 goes high, T3 turns on and D2 lights. Pressing the selector switch stops the oscillator and holds the counter at channel 0. If the selector switch is then pressed within the 'wait' time, a positive pulse from N5 will take the output of N9 high and trigger FF2, a 'D-type' flip-flop. By connecting the Q̄ output to the D input, the output of the flip-flop will 'toggle' each time a pulse is applied to the clock input. Once FF2 has been triggered, the oscillator will remain inhibited, since Ⓗ (the Q output of the flip-flop) is held high. T4 will be turned on, lighting the stand-by indicator D3.

The Monoselektor is taken out of the stand-by mode by pressing the selector switch twice in succession. This takes the Ⓓ line high once more, with the result that the output of N9 goes high, FF2 receives a clock pulse and the Q output of the flip-flop (Ⓗ) goes low.

Automatic reset

When the unit is first switched on, the automatic reset circuit (formed by T2, R8, R9, R10 and C6) generates a positive pulse of approximately 500 ms. This resets IC4, disables channels 1 . . . 11 and selects the stand-by mode by setting FF2 which in turn (via N8) inhibits the oscillator. As the Monoselektor is now in the stand-by mode LED D3 will be on.

Channels 1 . . . 11

These channels function in virtually the same way as channel 0 with only minor differences. The outputs of channels 1 . . . 11 are brought out via a buffer transistor. The main component of

channel 1 is FF3$_a$. When its Q output goes high, T6$_a$ is turned on, LED D5$_a$ lights to indicate that the channel is switched on, and the channel output is pulled low. Resistor R17$_a$ limits the current through T6$_a$ to a safe value, whilst diode D6$_a$ protects the LED against large reverse voltages. D7$_a$ protects T6$_a$ against inductively-caused back-EMF's. Channel 1 has been used here as an illustration, but the description applies also to channels 2 . . . 11.

Since the channel outputs are active-low, i.e. they are at logic '0' when switched *on*, relays should be connected between positive supply and the channel outputs.

Channels 12 . . . 15

Channels 12 . . . 15 each have two outputs and can be used as 'analogue' channels. Since they are identical, channel 12 will serve as an example for the rest.

When the Q12 output of IC5 goes high, LED D8$_l$ lights — indicating that this channel has been enabled. If the selector switch is now pressed, the D line goes high and the positive-going edge of this pulse will trigger FF12$_l$. If the Q output of this flip-flop was originally low, it is now taken high, with the result that both inputs of N13$_l$ will be high and T9$_l$ turned on. Thus, as long as Ⓓ remains high, the red LED, D12$_l$, will be lit and the R output of channel 12 will be low. If the selector switch is released and pressed a second time *within the 'wait' period*, the Q and Q̄ outputs of FF12$_l$ will change state, so that now both inputs of N12$_l$ are high. As long as the selector switch remains depressed, T8$_l$ is turned on, the *green* LED, D9$_l$ is lit and the L output of channel 12 is held low.

If desired, the current-limit resistors R22$_l$ and R27$_l$ can be reduced in value or shorted out, provided that the specifications of the transistors (T8$_l$, T9$_l$) are not exceeded (current ≤ 100 mA).

By connecting the two outputs to an electric motor (via a relay) such that it turns clockwise when the R output is low and anticlockwise when the L output is low it is possible to operate 'analogue' controls, such as the tuning dial on a radio etc.

Power supply

The circuit diagram of the power supply is shown in figure 5. The power supply is mounted on the same board as the circuit of figure 4. As can be seen, there are in fact two supply voltages: one for the LEDs (U$_O$) and one for the rest of the circuit. While the circuit supply is 'unspectacular', the LED power supply is somewhat more sophisticated. With the aid of a light dependent resistor the brightness of the LEDs is automatically varied to suit the ambient lighting conditions.

For example, in strong sunlight the resistance of the LDR (R32) will be extremely low, with the result that T10 will turn off and the base voltage of the Darlington pair T11/T12 increases, causing U$_O$ to rise. If there is little ambient light, however, the resistance of the LDR will increase, turning on T10 and causing the base voltage of T11 to fall. This in turn pulls down U$_O$, with the result that the LEDs become dimmer. Resistor R29, which is connected in parallel with the LDR, ensures that the LEDs are never completely extinguished. If the LEDs are not sufficiently bright in the dark, the value of this resistor should be reduced.

T13 ensures that the U$_O$ supply rail is short-circuit proof.

It has been found that, in some exceptional cases, using an unregulated supply for the main circuit can give rise to problems. If this situation should occur there is an easy answer: Construct a 12 volt 1 amp regulated power supply (using a 7812 for instance; see Elektor March 1979, E 47, p. 3-36) and connect its output across C7, taking care to ensure correct polarity. Diodes D15 . . . D18 can be omitted in this case.

Construction

The track pattern and component layout of the printed circuit board for the Monoselektor are shown in figures 6 and 7 respectively. Board assembly involves
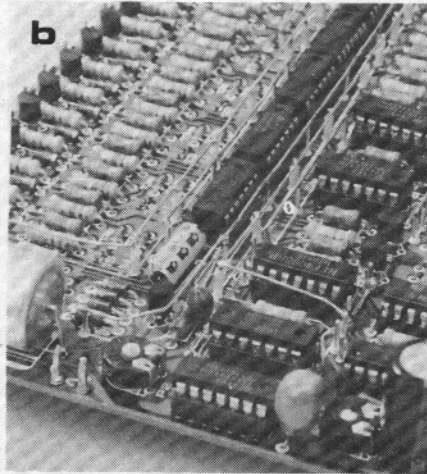
Figure 5. Power supply for the Monoselektor. With the aid of an LDR the brightness of the LEDs is automatically varied to suit the ambient lighting conditions.

Photo A. Example of board with all the components mounted in place. The use of IC sockets is recommended.

Photo B. A close-up of the wire-link connections which have to be made on the component side of the board.

Figure 6. Copper side of the p.c.b. for the Monoselektor. The LEDs and LDR are mounted on this side of the board.

Figure 7. Component overlay of the Monoselektor p.c.b. (EPS 79039).

(see overleaf)

a slightly unusual method of construction. The components printed in red on the component overlay, namely the LEDs and the LDR, are intended to be set into the front panel and are therefore mounted on the *copper* side of the board, not the component side. The anode connections of LEDs 4, 8, 9 and 15 are allowed to protrude through the board by about ¼ inch and are then commoned by a 'busbar' or wire link connections. An example of a finished board is shown in photo A, whilst the close-up (photo B) illustrates how the connections are made. The points where these connections are required are clearly indicated on the component overlay and should present no problem.

The 'wait' LED, D1, and the on/off LED, D19, are mounted on the front of the case, and connected to the circuit via insulated wire.

The light dependent resistor should of course 'see' the ambient lighting conditions, but must not be mounted such that it is exposed to direct light from the LEDs. The best solution is to provide a small opening in the front panel into which the LDR can be recessed.

Transistor T12 should be cooled and the simplest solution is therefore to mount it (making sure it is insulated by a mica washer!) on the back of the case.

A self adhesive front panel fascia, as shown in figure 1, is available through the Elektor print service (EPS). It would be desirable to have external access to preset potentiometers P1 and P2 so that the 'wait' period and the 'speed' of the running light can be varied. This can be made possible by drilling two holes in the front of the case at the points indicated on the front panel fascia. Other constructors may prefer to mount P1 and P2 on the back of the printed circuit board.

In conclusion

It will be apparent that the Monoselektor is essentially a control unit and therefore requires some form of interface between the channel outputs and the 'outside world'. This can take many forms depending on the user's requirements, although so called solid state switches would suit many applications. Further suggestions are given in the article — 'Switching mains powered equipment' (Elektor 49) which will be of some interest for this project (it could almost have been written for it . . .). ◄

The Monoselektor was the result of a design project by a study group at the Technical University of Eindhoven in Holland. The initial design requirement was for a simple-to-operate remote control unit for the handicapped and as such the Monoselektor has proved to be ideal. A number of systems have been in use in Holland for some time (saying a lot for its reliability).

6

Parts list

Resistors:
R1 = 10k
R2 = 6k8
R3,R7 = 4k7
R4 = 22k
R5, R11, R13, R15$_a$ ... R15$_k$,
  R18$_a$ ... R18$_k$, R20$_l$ ... R20$_o$,
  R23$_l$ ... R23$_o$, R26$_l$ ... R26$_o$,
  R33 = 120 Ω
R6, R8, R12, R14, R16$_a$ ...
  R16$_k$, R19$_a$ ... R19$_k$, R21$_l$ ...
  R21$_o$, R24$_l$ ... R24$_o$, R25$_l$ ...
  R25$_o$ = 3k3
R9, R10 = 100k
R17$_a$ ... R17$_k$, R22$_l$ ... R22$_o$,
  R27$_l$ ... R27$_o$ = 150 Ω
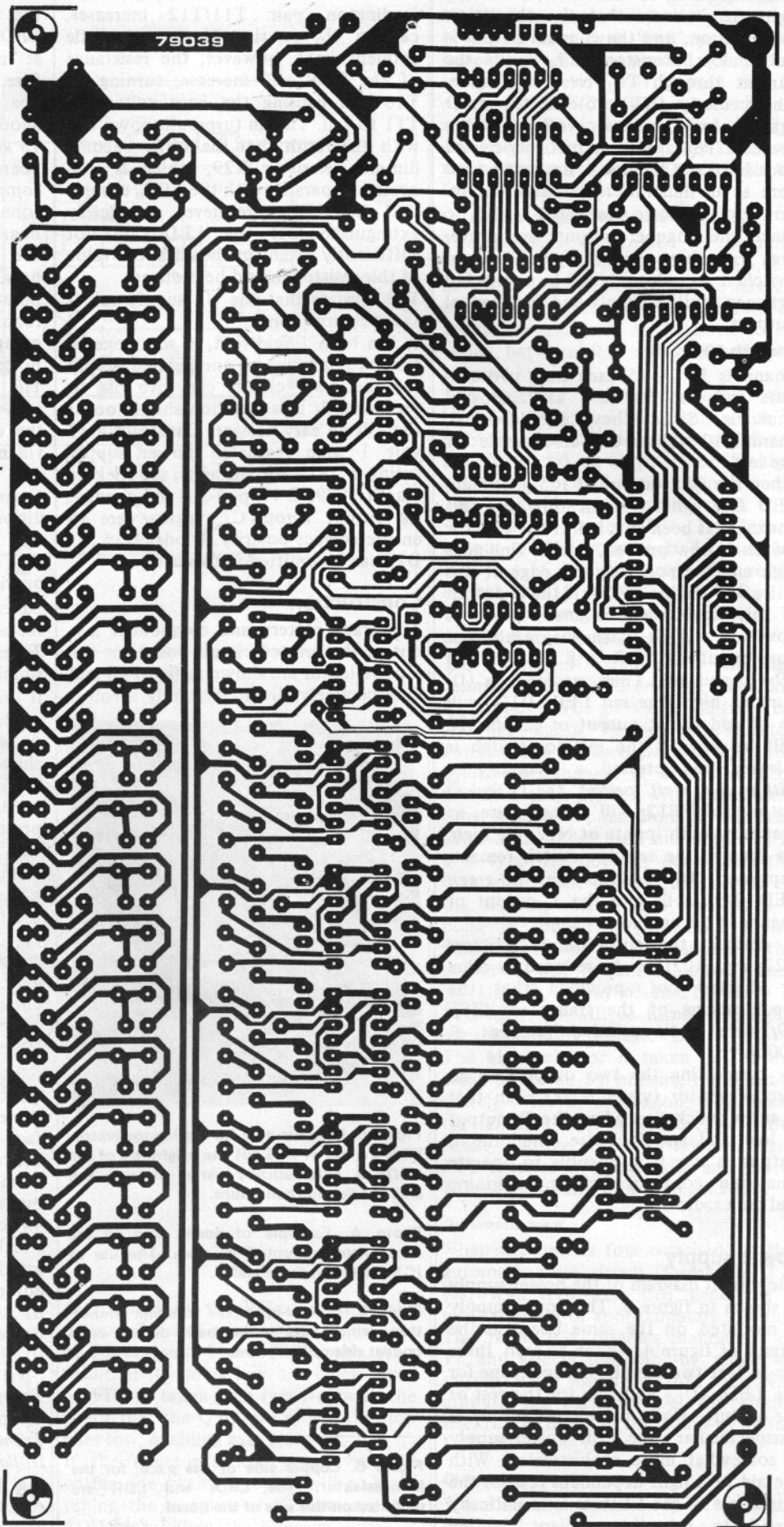R28 = 1k
R29 = 12k
R30 = 1 Ω
R31 = 27k
R32 = LDR
P1, P2 = 50k preset

Capacitors:
C1 = 1 μ/16 V
C2 = 22 μ/16 V
C3 = 470 μ/16 V
C4 = 10 μ/16 V
C5, C6 = 100 μ/16 V
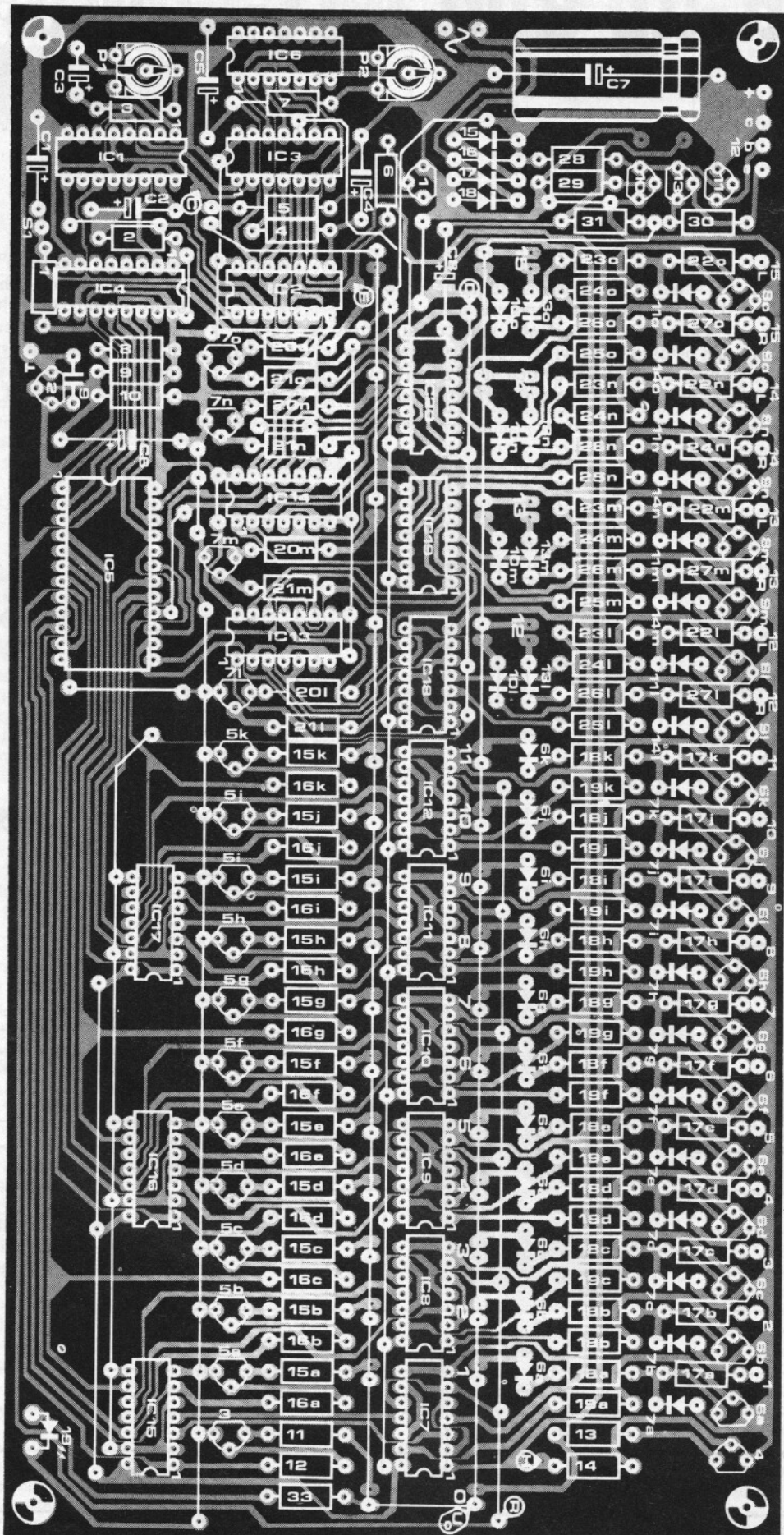C7 = 2200 μ/16 V
C8 = 47 μ/16 V
C9 = 10n

Semiconductors:
D1, D4$_a$ ... D4$_e$, D4$_g$ ... D4$_k$,
  D5$_a$ ... D5$_e$, D5$_g$ ... D5$_k$,
  D8$_l$ ... D8$_o$, D12$_l$ ... D12$_o$,
  D19 = LED red
D2, D3, D4$_f$, D5$_f$, D9$_l$ ... D9$_o$
  = LED green
D6$_a$ ... D6$_k$, D10$_l$ ... D10$_o$,
  D13$_l$ ... D13$_o$ = DUS
D7$_a$ ... D7$_k$, D11$_l$ ... D11$_o$,
  D14$_l$ ... D14$_o$, D15, D16, D17,
  D18 = 1N4001
T1, T2, T3, T4, T5$_a$ ... k, T6$_a$ ... k,
  T7$_l$ ... o, T8$_l$ ... o, T9$_l$ ... o, T10,
  T11, T13 = TUN
T12 = 2N3055 (heatsink!)
IC1 = 4528, 4098 (Motorola
  MC 14528, RCA CD 4098)
IC2 = 4093
IC3 = 4001
IC4 = 4520
IC5 = 4514
IC6 ... IC14 = 4013
IC15 ... IC20 = 4081

Miscellaneous:

S1 = SP switch
S2 = DP switch
F1 = 100 mA
Tr1 = trafo 6 ... 9 V, min. 0.5A
  (or 12 V, 0.5 ... 1A, see note)

7

Right-up and left-down

W. v. Rooyen

Don't ask us what the following circuit is intended to be used for – although we have no doubt that there must be some application for it. The author himself said: 'The circuit can be used to set a digital clock...' – which is quite true, as long as the clock uses TTL.

Anyway we are sure some inventive reader will come up with other possible applications.

Basically the circuit uses a 12-way switch (or any other number of ways, provided it is a multiple of three), and depending upon the direction in which the switch is rotated, a number of pulses are delivered to either the 'up'- or 'down' output. When the switch is left in one position, both outputs are held high. The switch must be of a break-before-make type, and the end-stop at the 12th position must be removed. ◄

1

N1 ... N3 = 7400 = IC1
N4 ... N6 = 7410 = IC2
N7 ... N11 = 7454 = IC3
N12 ... N16 = 7454 = IC4

79502 1

2

79502 2

MARKET

missing link

Modifications to
Additions to
Improvements on
Corrections in
Circuits published in Elektor

VHF/UHF TV modulator
Elektor 42, October 1978, and

TV games computer
Elektor 48, April 1979. Some readers have commented that the value given for C1 in the VHF/UHF modulator is 22p in the original article and 33p in the TV-games article. Either value may be used, although 22p is preferred.

Elekterminal
Elektor 44, December 1978. There are a few inconsistencies between the circuit diagram (figure 6) and the p.c. board (figure 7). These do not affect operation of the circuit, but may be misleading if the circuit is to be modified or extended:
- In figure 6, pin numbers 1 and 3 of N22 are transposed;
- the same applies to pins 12 and 13 of N23.

Furthermore, the 'b' and 'c' indications beside T3 on the component overlay are transposed; the copper layout is correct, so the transistor should be mounted as shown (ignoring the 'b' and 'c' indications).

BASIC microcomputer
Elektor 49, May 1979. For special applications (multi-processor systems and the like), the NHOLD and CONT connections to the SC/MP are brought out to the connector. Normally these will not be used, in which case 10k pull-up resistors should be included: one between pin 5c and pins 1a, b on the connector and one between pin 11c and pins 1a, b.

In figure 3, the indications X and Y for the two possible wire links to the NENIN input are transposed. For single-processor systems, wire link X should therefore be mounted on the board. The output of N2 (pin 11) is also brought out to the connector: connector pin 31a.

NIBL-E
Elektor 49, May 1979. In Table 1, in line 128∅ the second byte should be ∅E instead of 1E. Otherwise, the indication '\ERROR AT...' will be given instead of 'BRK AT...' (at end of program or after operating the 'Break' key).

Single board microcomputer

A new tutorial microcomputer system has been announced by Texas Instruments Limited. Intended primarily for colleges and universities the TM 990/189 M utilises a 16 bit CPU and is available fully assembled. The board is self-contained with 1K bytes of RAM (expandable on board to 2K) and 4K bytes of ROM (expandable on board to 6K). The 4K of ROM contains the system monitor 'unibug' and a symbolic assembler. The TM 990/189 M has its own cassette interface and is provided with a 45 key alphanumeric keyboard and a 10 digit, seven segment display. The display can
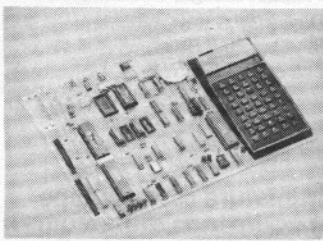
be shifted right or left to display any 10 characters in its 32 character buffer. Facilities to externally add a standard EIA terminal or TTY interface are also provided. Other features of this single board system include a series of addressable LEDs and a piezoelectric speaker. When the microcomputer is switched on, a group of four LEDs flash, the speaker beeps and the display then signals, "CPU READY". To indicate when the CPU is idle, when the keyboard is in the 'shifted mode' and the status of the cassette, other LEDs are used. A comprehensive applications textbook is also provided with the TM 990/189 M which gives instruction in microcomputer fundamentals, assembly and machine language and microcomputer interfacing.

*Microprocessor Product
Marketing Department,
Texas Instruments Limited,
Manton Lane,
Bedford, MK41 7PA.
(Tel. 0234 - 67466)*

(1195 M)

Relays and more relays

A new range of relays have been recently introduced by B and R Relays Limited. Called the E series, these low cost, general purpose, compact four-in-line relays offer a wide range of features and options. They are available in 2 or 4 pole double throw configurations with ratings from low level using bifurcated contacts to 3 Amps or 5 Amps

per pole. These relays occupy only 1.2 cu inches of space and come in dust-cover or hermetically sealed versions. There is also a washable vented type suitable for flow soldering assembly which features an adhesive tab that is removed after board cleaning to allow correct venting. Both solder and printed circuit mounting versions are offered with optional features such as a test button and mounting plate for top or side mounting. Sockets include snap-in as well as printed circuit versions. The small size and high reliability of 1.5 million operations (at 3A, 28V d.c.) should make the E series relays suitable for general automation, office equipment, copiers, computers etc. Specifications include coil voltages from 5 to 110 V d.c. and 6 to 240 V a.c. Maximum coil dissipation is 2.0 Watts and contact operate time is 13 ms. Operating temperature range is −40 to +70°C and shock and vibration resistance are to 10g and 5g respectively.

*B and R Relays Limited,
Templefields, Harlow, CM20 2BG,
Essex. (Tel. 0279-34561)*

(1189 M)

Solid-State software!

A plug-in module for the TI58/59 programmable calculators containing business decisions software has been launched by Texas Instruments Limited. The

software library contains a range of programs designed to ease the basic tasks involved in business decisions, and enables managers to have instant access to, and awareness of, processes that are normally handled by computers. In addition the library provides a number of programs which can be incorporated in specific routines for a particular company without the need to produce programs involving detailed

analysis of specific techniques such as demand forecasting or economic ordering.

*Texas Instruments Limited,
European Consumer Division,
Manton Lane, Bedford,
MK42 7PA.*

(1188 M)

Combined oscilloscope and digital multimeter

A new service instrument from Tektronix, the model 305, combines a dual trace oscilloscope with a full-function autoranging digital multimeter.
The oscilloscope functions of the model 305 combine 5 MHz bandwidth with 5 mV sensitivity, sweep speed from 1 μs to 50 ms per division (with an X10 magnifier providing 0.1 μs per division), full X/Y capability and a range of channel modes and trigger facilities have been incorporated. The multimeter section covers 12 voltage and resistance ranges up to a maximum of 1 kV DC or 700 V AC and a maximum
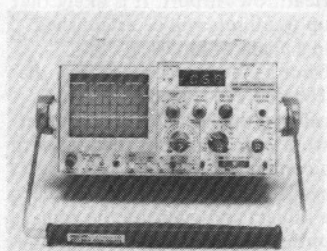
resistance of 2 MΩ. Accuracy on the DC voltage range is ± 0.1%. The whole package measures only 11.2 x 23.7 x 36.0 cm and weighs only 4.8 kg including a built-in rechargeable battery pack. The instrument's portability and wide range of measurement functions make the 305 ideally suited to field servicing. It is equipped with a carrying strap which allows the user to keep both hands free, and can be operated easily on catwalks, ladders and in confined spaces normally inaccessible for testing purposes.
The model 305 can be operated from AC or DC supplies as well as from the internal rechargeable battery pack. Typical power consumption is 15 W, and battery life 5 hours for oscilloscope operation only and 3½ hours with both oscilloscope and multimeter in operation.

*Tektronix U.K. Ltd.,
Beaverton House,
P.O. Box 69,
Harpenden,
Herts*

MARKET

UK launches first slot-machine TV newspaper

The world's first coin-operated computerised public information service has been launched in Britain.

Slot-machine television sets which will begin to appear in hotels, shops, clubs, airports and other places will bring Britain's advanced teletext system Viewdata within everyone's reach. Until now this latest Post Office communications service has been available only to those who rent special TV sets.

A year ago, the Post Office joined with the British Cherry Leisure company to investigate the possibility of producing a coin-operated Viewdata TV terminal. Cherry Leisure is a subsidiary of one of the world's largest operators of fruit, vending and video machines.

By last September, the first prototypes had received Post Office approval and coin-operated sets have been in production in the UK since October. The first installation, formally handed over on 24 January, is in the foyer of a London hotel and other sets are about to be set up in a Central London post office and a passenger waiting area at London's Heathrow Airport. It is likely that up to 50 sets will be established in a chain of hotels.

Once a coin has been fed into the TV set a call is made automatically to the Post Office computer store which provides the user with a contents sheet of information available. The user can then select a subject and question the computer. As well as information on such matters as stock market prices, sports results and weather forecast, the system can offer a series of games and will even help the user to write a poem by offering rhyming words.

(469S)

Versatile connector

The new Intra-Connector from Lektrokit permits quick testing of previously inaccessible interconnect lines. The single-piece unit comprises a male and female connector that can be simply and quickly interposed between a plug and socket.

A pin connection for every contact is brought out to a probe pin on the top of the Intra-Connector. This offers a fast and simple access for electrical monitoring of individual lines without physical disturbance. Daisy chaining from a single connector cable end is also possible. There are five Intra-Connect units in the Lektrokit range with 20, 26, 34, 40, and 50 contacts
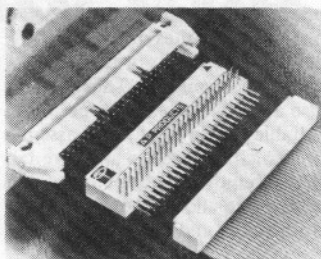
respectively. Pins are on a standard 0. lin. pitch as are the test pins that protrude at right angles from the Intra-Connect body to a height of 0.24in. (typ.). Contacts are non-corrosive alloy 770 while the body material is a high grade glass loaded polyester. The Intra-Connector will mate with any standard 0.1 x 0. lin. dual row connectors.

Lektrokit Ltd., Sutton Industrial Park, London Road, Earley, Reading RG6 1AZ, Berks. (Tel. 0734-66 91 16/7)

(1192 M)

Something new in C.R.T. systems

A totally modular C.R.T. electronics system called Visionpack has been announced by Digivision. The system is comprised of five plug together modules which are based upon proven circuitry and components. By dispensing with the problems of dealing with high voltage C.R.T. circuits, Visionpack enables the designer with little experience of TV type circuitry to produce a design for an overall piece of data display equipment. The main interface unit, the Horizontal Scanning Module (1), is connected to the Line Output Transformer Module (2) which produces the auxiliary voltages required by the system. This module is connected to the Vertical Timebase Module (3). A Video Amplifier Module (4) is mounted with the C.R.T. base

connector on a small round printed circuit board, while the Scanning Yoke Assembly (5) is fitted to the neck of the C.R.T. The Scanning Yoke Assembly will fit most 20 mm C.R.T.'s in the size range of 7 to 14". The five fibreglass printed circuit boards are electrically interconnected via the Pressac 200 connector system. Low cost snap on-off locking pillars can be used to mount modules 1, 2 and 3 to a conventional base plate or chassis. The modules can be replaced quickly and simply, and the cost of each module is low enough that they can be discarded rather than repaired. Visionpack gives flexibility to the design of data display equipment and its rugged construction gives it reliability.

*Digivision, 82, Cannock Road, Leicester LE4 7HR.*

(1197 M)

Miniature cassette tape deck

For all you do-it-yourself (micro) computer builders thinking about how and where to mount your tape recorder system take a look
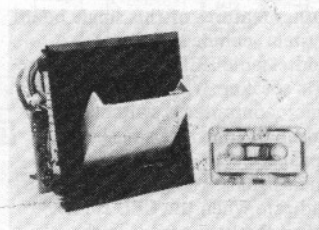
at the CM 600miniature cassette transport system now available from BFI Electronics Limited. The complete transport is self-contained (76 x 76 x 64 mm), light (230 g) and includes all necessary Read/Write amplifiers and control circuitry. The CM600 has a two-track recording head which produces a recording
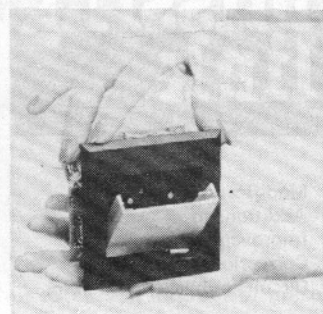
density of 800 Bits/inch (maximum) and a data rate of 2400 Baud. It has a reel-to-reel drive system developing an average forward search speed of 5 i.p.s. and rewind speed of 15 i.p.s. The data capacity of a standard 100 ft miniature tape cassette is 1.6 MBits while the total Read/Write time is 5 minutes 40 seconds. Operation of the CM600 is controlled entirely by external electronic logic signals. Typically these represent tape direction (forward/release), tape motion (stop/go), tape speed (fast/slow), select Read/Write and data input. Output lines carry data, and indicate the cassette side being used, cassette presence, clear leader, etc. The transport can be operated at any angle between horizontal and vertical while power consumption is typically less than 1 Watt from a single +5 volt supply.

BFI Electronics Limited, 516 Walton Road, West Molesey, Surrey, KT8 OQF. (Tel. 01-941 4066).

(1191 M)

Magnitude comparator for control applications

A new 4-bit magnitude comparator is available from RCA Solid State. Designated the CD 4585B, this device was designed for servo-motor controls, process controllers, and other logic applications that require the comparison of two 4-bit words. The circuit can determine whether one 4-bit word (binary or binary-coded-decimal) is 'less than', 'equal to', or 'greater than' a second 4-bit word. The CD 4585B has eight comparing inputs, three outputs and three cascading inputs which allow expansion of the comparator functions in multiples of four bits. Speed of operation is typically 180 ns at 10 V, maximum input current is 1 μA at 10 V and 100 nA at 18 V. The integrated circuit is available in 16-lead plastic or hermetic ceramic dual-in-line packages or in chip form.

RCA Solid State - - - Europe, Sunbury-on-Thames, Middlesex, TW16 7HW.

(1199 M)
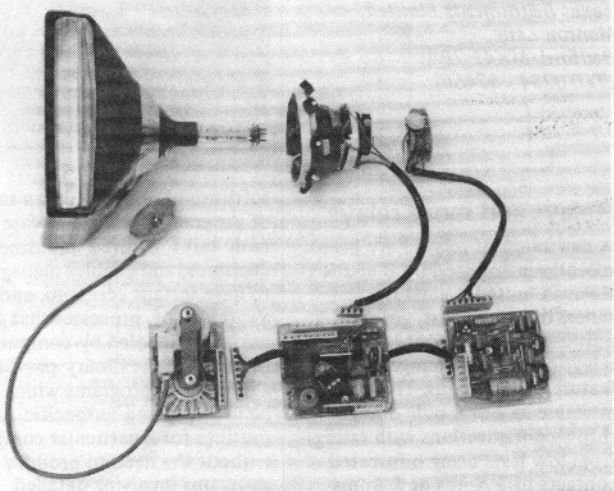
MARKET

Intelligent alphanumeric display

Litronix have introduced two new alphanumeric displays to their range of optoelectronic devices which incorporate no less than 17 segments per character! Is this a record? Both new devices, the DL-1414 and the DL-2416, consists of four charcters and have their own decoding, memory, multiplexing, driving and control circuitry. Additional features are computer optimised lens for magnification with minimum distortion and end-to-end stackability. Their inputs are TTL compatible, as are their power supply requirements and each device contains ASCII coding to segment conversion and input static RAM buffering (no refresh). The DL-1414 display has a 0.112 in. character height, requires low power supply and can be battery operated, as a result being ideally suited for hand-held devices. The DL-2416 has a 0.16in. character height, wide viewing angle, fast access time and is a small rugged package in standard DIP form. These 'intelligent' displays afford considerable ease of use by connecting data inputs directly (buffered if required) connecting address inputs to address bus, using CE to expand displays, generating single write pulse and having cursor facility if required.

Litronix Inc., 23 Churchgate, Hitchin, Herts, SG5 1DN.

(1190 M)

Pretty boxes, little boxes - - -

No, these boxes are not made from 'ticky-tacky', but are moulded in ABS. They are part of the new Pac Tec 'C' Series range of enclosures from OK Machine and Tool (UK) Limited. These cases are available in over 25 sizes and have been designed to provide

versatile and purpose-built packages for a host of electronic or electro-mechanical instruments. They are made up from single components — top, bottom, sides and ends — are dust and splashproof when assembled and can be supplied in beige, black or blue textured colours requiring no extra furnishing. Standard width is 212 mm, depth is 232 mm with height ranging from 62 mm to 88 mm in 6 mm increments. In addition a Mini Series is also offered with dimensions starting at 37 mm high x 130 mm wide x 144 mm deep. Vertical circuit board guides are fitted and options include rail and card slide adaptors, standard or special front and rear panels, RFI/EMI shielding, handles and tilt stands.

OK Machine and Tool (UK) Ltd., 48a, The Avenue, Southampton, Hants. SO1 2SY (Tel. 0703 - 38966/7)

(1196 M)

Temperature controller chip

A universal digital thermometer/ controller microcircuit has been announced by General Instrument Microelectronics Limited. This device can be used in many applications including the control of home heating, cooling and air conditioning systems. This new chip, designated type AY-3-1270, will measure the temperatures found in domestic and commercial equipment and display them on LED or LDC display panels. The device will accept inputs direct from a thermistor temperature sensor, and will drive the display without interface circuitry. The AY-3-1270 includes an on-chip power failure detector, which provides warning if power has been removed for longer than a specified time. It also provides warning should temperatures vary outside normal levels (the display

will flash until manually reset). Two control outputs are provided, one operating at set point plus hysteresis and the other at set point minus hysteresis. Accuracy of temperature sensing is ± 1° C, and hysteresis can be set to various values between 0 and 8 degrees. In addition, control output and display jitter has been avoided by the inclusion of 0.05° display hysteresis. With minor changes to the pheripheral circuitry, (change of thermistor type) the AY-3-1270 can be used to measure different temperature ranges. Furthermore, the chip can be used as the heart of a 3¾ digit digital voltmeter with automatic zero. Power requirements are not critical, a single 9 V, 40 mA supply being all that is needed. The package is a 40 pin dual-in-line type suitable for use in ambient temperatures from −25° C to +70° C.

General Instrument Microelectronics Ltd., Regency House, 1-4 Warwick Street, London W1R 5 WB, England (Tel. 01-439 1891)

(1198 M)

Digital logic probe

Until recently digital electronics servicing had to rely on the oscilloscope for logic level analysis. Although accurate and sensitive, the oscilloscope is generally expensive and not very portable. However, this new probe from OK Machine and Tool (UK) Ltd. is said to rival the best oscilloscopes in performance, is completely portable and is lower in cost than most comparable units.
This pen-sized probe, the PRB-1, is powered by the circuit under test and is fully compatible with all logic 'families' thereby simplifying the task of trouble-shooting in even the most sophisticated circuits. To ensure reliable detection of logic signals the thresholds are set at 60 percent (high) and 15 percent (low) of supply voltage and the unit is permanently adjusted so that no recalibration is required. Furthermore, no switch resetting or manual adjustments are needed to go from one IC family to another. The probe body is both impact, and solvent resistant. The light weight power cord is coiled for convenience, detachable, and extends to 6ft (1.8 m) if necessary, terminating in mini-alligator clips. The constant brightness LEDs are situated for maximum visibility, and a logic truth table is printed above them. The probe is sensitive enough to detect a pulse of less than 10 ns over a voltage range of 4 - 15 VDC. Frequency response
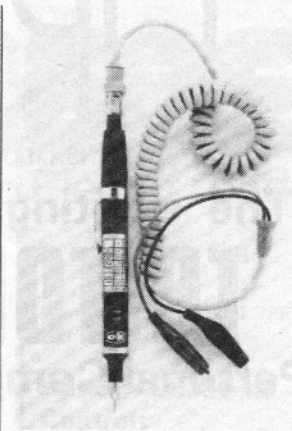
is DC to 50 MHz over the same voltage range. A 'pulse stretching' memory retains short pulses for 50 ms, allowing reliable observation, then resets automatically. The probe also indicates an open circuit or high impedance condition by extinguishing both LEDs.
The PRB-1 is protected from overloads up to ± 70 VDC and has an impedance of 120 kohms making it virtually 'invisible' to the circuit under test. The probe itself draws only 0.5 mA at 2.5 V with both LEDs driven, and only 15 μA on standby.

OK Machine and Tool (UK) Ltd., 48a, The Avenue, Southampton, Hants, SO1 2SY. (Tel. 0703 - 38966/7)
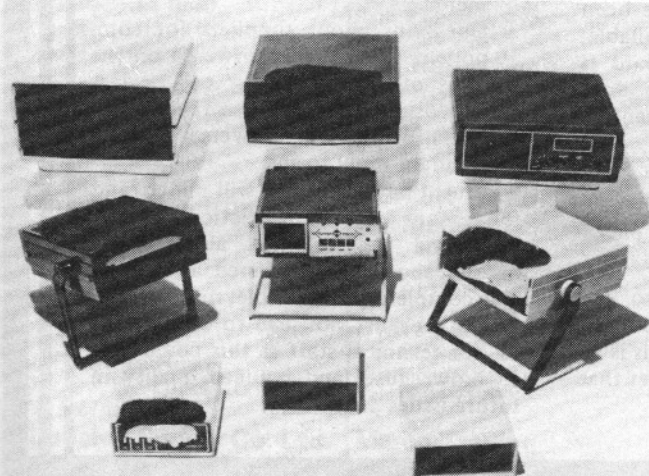
(1194 M)

Transformers

A new range of transformers has been announced by Verospeed. The transformers are provided with two 120 volt primary windings, which may be connected in series or parallel for 50 and 60 Hz operation, and two secondary windings with output voltages ranging from 0-3 V to 0-20 V rated at between 1.2 VA
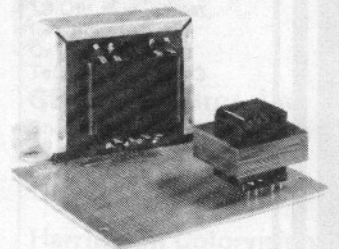
and 50 VA. All transformers in the range are fitted with full shrouds and are varnish protected.

Verospeed, Barton Park Industrial Estate, Eastleigh, Hampshire, SO5 5RR. (Tel. 0703-61 85 25)

(1193 M)